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MUNICIPAL OWNERSHIP OF WATER-WORKS in and about London, England, will be accomplished on June 24, 1904, in accordance with the Metropolis Water Act of 1902. This parliamentary act is the result of many years' agitation. From an analysis of its provisions by Thomas Hennell, C. E., the following abstract has been made. The property of the eight water companies now supplying London and its immediate vicinity are to be transferred to a water board at agreed prices, or for sums fixed by three arbitrators, who are also to pass upon any other disputed questions arising in connection with the transfer. The arbitrators were named in the act as follows: Lord Justice Fry (since deceased); Sir Hugh Owen; Sir John Wolfe Barry, Past-Pres. Inst C. E. Included in the transfer will also be the small municipal plants now supplying Tottenham and Enfield. The Metropolitan Water Board is to consist of 66 members, appointed as follows: 14 by the London County Council; two each by the (old) city of London, one each by the city of Westminster; one each by the 27 other metropolitan boroughs; one each by five county councils outside the administrative county of London, and 12 by the local authorities within those five counties; two by the county borough of West Ham; and two by the Conservators of the Rivers Thames and Lea. The 66 members thus selected are to appoint a chairman and a vice-chairman, who may or may not be members of the representative board, and who may be paid if the board so orders. Money may be borrowed to pay the companies on 80-year loans, and for other purposes on 60-year loans. The board may also issue a 3% water stock, which shall be used to pay the New River Co., and may be taken in place of cash by the other companies, if they so elect. The board must continue the water rates charged by the companies, and must not reduce those rates if such reductions would, or would be likely, to cause a deficiency. In case deficiencies do arise in any financial year they are to be apportioned between the districts represented on the board, "in accordance," to quote Mr. Hennell, "with the rateable value of the hereditaments for the time being actually supplied with water in each place." The board must make chemical and bacterial examinations of the water supplied under its direction. The population of what may be termed Greater London was 4,536,541 in 1901, and it is represented by a total of 45 members. The outside areas have a combined population of 1,645,000. This makes a total of nearly 6,200,000, besides which portions of various other places, with a population of 215,000, are to be supplied.

AN INTERNATIONAL COMPETITION for canal lift works has been instituted by the Austrian government. Prizes of 100,000 kronen, 75,000 kronen and 50,000 kronen are offered (the crown is worth about 20 cents). The special case for which a solution is desired is a difference in level of 35.9 m. (117.8 ft.) in the Donau-Oder Canal at Aujezd, Moravia. The lifting works are to require a minimum amount of water at the lowest possible cost of operation. Vessels up to a size of 67 m. total length by 8.2 m. breadth by 1.8 m. draft (219.8 ft. × 26.9 ft. × 5.9 ft.) are to be accommodated, and the lifting works must have a capacity of 30 vessels of maximum size each way per day of 24 hrs. A commission of nine engineers will constitute the board of judges. Designs not awarded a prize may be acquired by the Austrian government for a stipulated sum of 25,000 kronen each. In case one of the designs submitted is built and after two years' operation proves entirely satisfactory, the author of the design will receive a premium of 200,000 kronen. The competition closes March 31, 1904; designs will be received, in a specified form, by the Imperial Ministry of Commerce, Vienna. The condition of the competition, plans with contours, borings, etc., are detailed in the "Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereins," (address, I. Eschenbachgasse, No. 9, Vienna), of May 1, 1903.

PIERS LONGER THAN 800 FT. are desired by the transatlantic steamship lines entering New York city. The War Department of the Federal government, which has control over the channel of the Hudson River, has repeatedly been asked to permit extending the piers into the river 200 ft. beyond the present established pier-head line. A board of engineer officers ordered to investigate the matter reported, about a year ago, that such extension should not be permitted as the channel is now none too wide for the needs of the shipping; the department accordingly refused the request. Recently the city of New York, through its mayor and its dock commissioner, applied for a revision of the refusal, as it is building a series of new large docks which it desired to make 1,000 ft. long without encroaching further landward. In response to this the War Department detailed Gen. Gillespie, Chief of Engineers, to again investigate the matter, and he has just reported his findings to the Secretary of War. The channel of the Hudson River is now less than 3,000 ft. wide, and the proposed 200-ft. reduction, with an equal reduction on the New Jersey side (also applied for) would reduce its width to 2,400 ft. He considers the reduction to be inadvisable. It should be remembered that besides the ocean traffic entering the river for docking there is a large up-river traffic and a very great amount of ferry traffic across the river; the ferrying includes passenger ferries, freight lighters and car ferries connecting the various railroad yards on the East River and both shores of the Hudson. In addition there is the harbor service of tugs, etc., which is not inconsiderable. Under present conditions each winter season, with its foggy weather, brings a number of collisions, principally between ferries, sometimes with serious results. This evidence of the crowded condition of the river should be a sufficient argument against reducing the channel by 15%.

A NAVAL EXAMINING BOARD, for the examination of such candidates for admission to the service as civil engineers and assistant civil engineers, has been ordered by the Secretary of the Navy to convene at the Navy Yard, New York, on June 1. The officers composing the board are: President, Civil Engineer Robert E. Peary, U. S. N.; Members, Civil Engineers F. T. Chambers, U. S. N.; Fred. Thompson, U. S. N., and Leonard M. Cox, U. S. N.; Recorder, Civil Engineer C. A. Wentworth, U. S. N. The examination of candidates will begin on June 8, and will conclude on June 20. The following rules are adopted governing appointments of assistant civil engineers in the Navy:

No person shall be appointed who is less than 23 or more than 28 years of age. Candidates for appointment shall be examined as to their physical fitness by a board of medical officers of the Navy, and as to their mental and professional qualifications by a board of such officers as the Secretary of the Navy may designate for the purpose. The physical examination shall precede the mental and professional, and if a candidate is found physically unfit for appointment he shall not be further examined. Application for permits to be examined must be made to the Secretary of the Navy, and must be accompanied by testimonials as to character, evidence of American citizenship, evidence of having received a degree in the civil engineering course of some professional institution of good repute, and a record of at least two years' practical experience as a civil engineer. The mental and professional examination will be competitive and in writing, and will comprise such subjects as the following: Testimonials and adaptability; English grammar and composition; elementary physics; elementary geology; drawing; arithmetic; algebra, geometry; trigonometry; analytical geometry; differential and integral calculus; applied mathematics, including mechanics of solids and fluids and strains in structures; electricity; construction materials; engineering construction, such as workshops, steam and electrical machinery, quay walls, wharves, sewers, yard railways, pavements, water distribution, foundations, etc.; surveying (topographical, trigonometrical, and hydrographical) and mapping; instruments, their use and adjustment. Candidates who pass satisfactorily will be arranged by the board in the order of their relative merit as determined by such examination, but no candidate will be considered as having passed a satisfactory examination who does not attain a general average of 80%.

A CIVIL SERVICE EXAMINATION will be held at the Navy Yard, New York, on May 28, for the position of draftsman in charge in the Department of Yards and Docks. The salary is $6 per day. Applications should be addressed to the "Commandant, Navy Yard, New York, N. Y.," and should be delivered by May 27.

SUBMARINE TORPEDO BOATS of the Holland type, tested recently preliminary to acceptance by the United States Government, appear to have given satisfactory results; that is, fulfilled their contract requirements. The contract speed, submerged, is 7 miles an hour, which was reached or slightly exceeded. The underwater qualities of the boats were tested by making a run of one mile, submerged, and at the end of the run firing a torpedo which was required to pass between two buoys set 150 ft. apart.

A TURBINE STEAMER CROSSED THE ATLANTIC a week or two ago. The steam yacht "Emerald," 236 ft. long, 29 ft. wide and 18½ ft. deep, was chartered from her English owners by an American, who had the vessel brought to this country under her own power. The trip was made in very stormy weather, and only half speed (400 r. p. m. against normal speed of 700 r. p. m.) was used during the larger part of the voyage. The vessel has three screw shafts, of which the outer two carry two screws each, but on the occasion of this voyage, there was only one screw on each shaft.

THE MERSEY TUNNEL RAILWAY, connecting Liverpool and Birkenhead, England, began operating its trains by electricity on May 3. The Mersey tunnel was opened on Feb. 1, 1886, and has been operated up to the present time by steam locomotives. The line has very steep grades on either side, the incline being 1 in 27, and the total descent about 150 ft. A very elaborate fan-ventilation system was provided, but as the tunnel had to be ventilated from each end, it was never thoroughly satisfactory. The operating expenses of the tunnel railway have always been very heavy. In the six months ending in December, 1902, the operating expenses were 95% of the gross receipts. This is in part explained by the competition of the ferry lines across the Mersey, which have greatly increased their patronage since electric railway lines were built connecting with them. The contract for the installation of electric traction on the Mersey tunnel railway was made in July 1901 with the British Westinghouse Co. As described in "Transport," the trains are made up of two motor cars and two to three trail cars. Each motor car has four 100-HP. motors. Trains are run at 3-minute intervals during 19 hours out of the 24.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Baltimore & Ohio Ry. near Bloomingburg, O., on May 14. A passenger train was derailed, probably through spreading of the rails, and two trainmen were killed.

SEPTIC TANKS EXPLODED at Sheringham, Norfolk Co., England, on May 1, killing two persons and seriously injuring five others. The tanks had flat concrete tops, and occupied a space of about 240 × 150 ft. The cause of the explosion and the extent of the damage to the tanks is not definitely stated. The following item is from the London "Surveyor" of May 8:

At the inquest on the bodies of the victims of the explosion, on Monday, the coroner, after hearing the evidence, said that in his opinion there had been a slipshod way of cautioning the men as to the use of lights. In the end the jury found that the district council were to blame, as, in their opinion, they ought to have been more strict in their supervision of the septic tanks and the adjoining works. They considered, also, that workmen ought not to be allowed to go into the inspection chambers without proper supervision.

AN INJUNCTION AGAINST POLLUTING the Menomonee River by the discharge of sewage from the 30th St. sewer outlet, at Milwaukee, Wis., has been granted at the instance of Mr. Henry Thrill. The Judge held that septic tanks were the most feasible, evidently because the most speedy means of relief, and it appears that the city was given until Nov. 1, 1903, to construct such tanks. The sewer in question, it is said, serves 1,722 acres in the western and northern parts of the city. An appeal to the State Supreme Court will probably be taken.

THE UTILIZATION OF UTAH LAKE AS A RESERVOIR.

By W. P. Hardesty, C. E.*

The increasing importance of reservoirs in the irrigation development of the arid region has of late years directed attention to the numerous sites for the storage of water that exist through different parts of the West. Of these, none comes nearer being a "natural" reservoir, nor possesses more points of interest, than the subject of this article.

Utah Lake is situated in Utah county, in central Utah, and its north end is about 30 miles due south of Salt Lake City. The lake has an extreme length, north and south, of about 23 miles, and an extreme width of about 15 miles. The area at normal stages of water is about 145 square miles. The lake occupies a subsidiary basin of Lake Bonneville, the ancient basin of Great Salt Lake.

The Jordan River is the outlet of Utah Lake. This river heads at the north end of the lake, and runs directly north into Salt Lake county and through Salt Lake City, finally discharging into Great Salt Lake about nine miles northwest of the city.

Utah Lake has a watershed of about 3,000 square miles. The principal feeders are the Provo, American Fork and Spanish Fork rivers, the former being much the largest. Besides these and smaller streams, there is much drainage directly into the lake, most of which originates from the irrigation on the slopes draining toward the lake, and reaches it through numerous sloughs and spring runs.

The mean annual rainfall over the watershed of the lake for a period of years has been, as near as can be ascertained, about 14 ins., and applying these figures gives a total volume in acre-feet of 2,240,000. This would cover the lake (taking its mean area as 93,000 acres) to a depth of 24.1 ft.

There are several reasons why only a small fraction of this depth has so far ever been utilized in one season. Under natural conditions, only 40% or 50% of the total precipitation could ever reach the lake, and the extensive irrigation that is carried on under the mountain streams that feed it results in so much of the water turned on to the lands being absorbed or evaporated, that it is not probable that over 30% of the rainfall during ordinary years ever reaches the lake.

In addition to this, the evaporation from the lake is enormous. The water is very shallow over most of its area. The land on all but the west and southeast sides of the lake is quite flat, sloping toward the lake at the rate of from 1 to 5 ft. in 1,000 ft. The beach and bottom for the entire circumference have the same light inclination. This also rapidly flattens out, so that the average depth of water during ordinary stages is probably about 8 ft., and the extreme depth is thought to be about 15 to 18 ft. Evaporation from this shallow basin, where the water, for its entire depth, as well as the bottom, become heated by the sun, is, of course, quite rapid, and this forms one of the greatest obstacles to the full use of the lake as a reservoir. The shore line of the lake was surveyed in 1889 by the U. S. Geological Survey, and it was segregated as a reservoir, all vacant public land around the shore being withdrawn from entry.

The Jordan River, after leaving the lake, has an extremely tortuous, general northerly, course for some miles, with low-lying lands on either side. It is then confined between bench lands that increase in height as the river continues northward, the natural fall of the river being extremely light, however, until the low range of mountains that forms the divide between Utah and Salt Lake counties (and the valleys of the same names) is reached. The river runs through this in a gorge known as "Jordan Narrows." The fall here is much more rapid, amounting to about 80 ft. in less than 2½ miles. Below the "Narrows" the fall is again light. The natural fall in the 10 miles' length of river to the head of the "Narrows" is only about 3 ft. This peculiar condition renders it possible, by placing a timber dam across the river at this point, to back the water up in the river clear to the lake, and to thus have almost complete control over the outflow from the lake.

Under natural conditions, there is a mean annual range in level of the lake's surface of 2 to 4 ft., the water being highest at the end of the spring floods and lowest late in the fall, before the winter storms set in. The outflow through the river varies in like manner.

The Jordan River is the most important river in the state, as regards irrigation. The lands irrigated from it lie in the thickly-settled Salt Lake Valley, and their products find a ready sale (or advantageous shipping point) on account of their being situated so closely to a large center of population. Over 30 years ago, the first large canal (the South Jordan) was started from the river, and four other large ones and some smaller ones have been taken out since.

During 1872-74, the Utah & Salt Lake Canal was built, on the west side of the river. In order to cover as much ground as possible, the head of this was located so high that the timber dam built across the river, near the head of the Narrows, for diverting water into it, caused the water to be backed up into Utah Lake. This dam also served to divert water into the East Jordan Canal, built on the east side of the river.

Both for the purpose of storing water in the lake, and for diverting it into the canals, it was customary for several years to hold the water back and to raise the level of the lake to almost any elevation desired. This resulted in flooding the low lands around Utah Lake, rendering them almost unfit for use. The contentions with the owners of these lands culminated in a lawsuit in 1884. This suit resulted in a compromise, made in 1885, by which a certain level, called "compromise level," was fixed, above which the water is not supposed to be raised. The regulations of the outflow of the lake is in the hands of a commission of five members, selected as provided for by the compromise. The elevation of this point, by the datum used here, is 4,515.8 ft. above sea level. Water at approximately this level is spoken of in this article as the "normal" stage.

The lake in the early summer of 1884 reached a height about 5 ft. above compromise, which is the highest level of which there is any accurate record. The winter of 1888-89 was an uncommonly dry one, so that the lake, which had been falling for several years, received but little water during the following spring, and by late summer it had fallen so low that certain bars at the outlet had to be removed to allow any water at all to enter the river. The compromise low water level, below which the lake fell 9 ins., is 3 ft. 3½ ins. below the compromise level.

The bottom of the Utah & Salt Lake canal had to be lowered at enormous expense, after the establishment of the compromise level, in order to draw off water at the reduced stage above the dam that then became allowable.

In 1890, a new dam was built across the river, for the purpose of better regulation of the storage of water in the lake. This dam is about ¾-mile above the other one, just above the "Narrows," and is known as the "New Dam," while

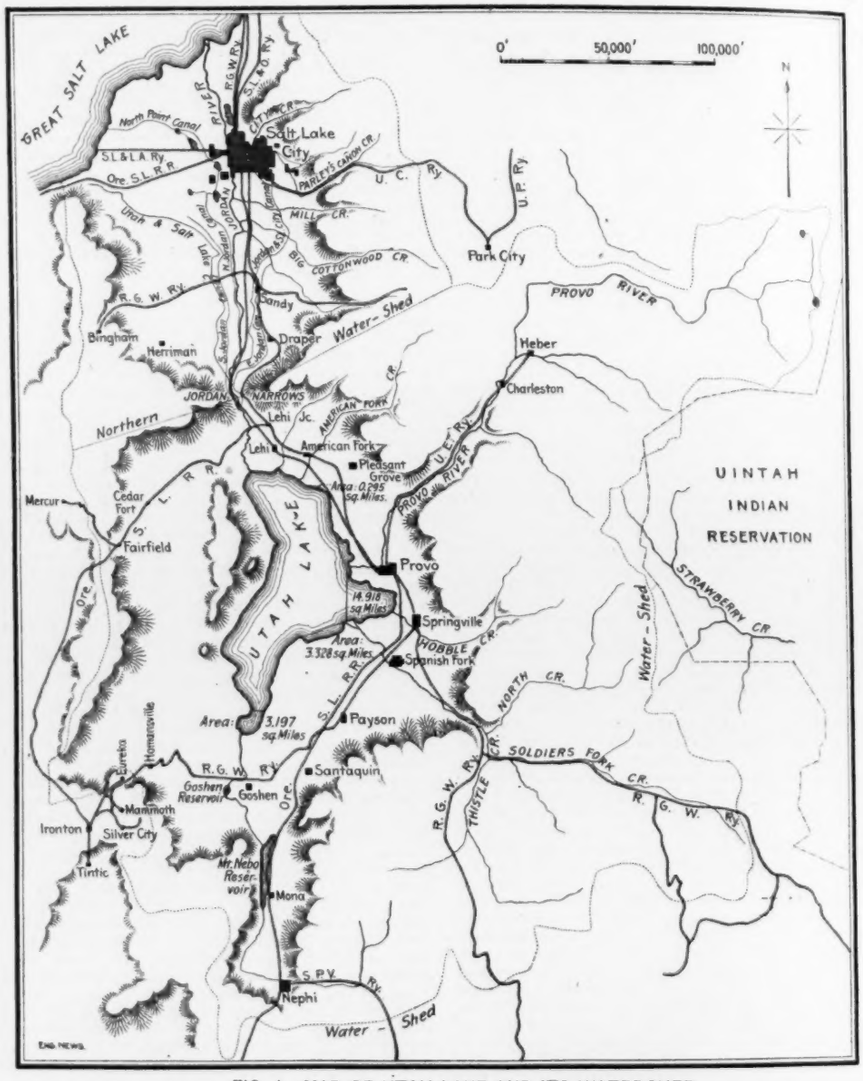


FIG. 1. MAP OF UTAH LAKE AND ITS WATERSHED.

*Progress Building, Salt Lake City, Utah.

the old one, which is still used for regulating entry of water to the two canals, is called the "Old Dam."

The "New Dam" is a little over 10 miles, by the windings of the river, from the lake, and is a substantial wooden structure. Its sill is about 6 ft. 1 in. below compromise level, being near the bottom of the river, and, by means of flash boards, the flow of water through its ten openings is reduced to any desired amount, or entirely cut off. The dam was built and is maintained by the city of Salt Lake and the four larger canal companies taking water from the river, the interests of the five canals concerned being looked after by what is called "The Board of Canal Presidents." On this board, an official of Salt Lake City, usually the City Engineer, represents the city.

These canals, and the acreage that can be supplied by each when there is an abundant supply of water, are as follows:

Utah and Salt Lake	12,000	acres.
South Jordan	9,600	"
North Jordan	5,600	"
East Jordan	9,000	"
Jordan and Salt Lake City, called "City Canal"	9,000	"
Total	45,200	acres.

All but the last two lie on the west side of the river and of Salt Lake valley.

Though this partial use of the lake as a reservoir has been of great benefit, of late years it has grown more and more apparent that radical measures were necessary for a full utilization of the waters that enter the lake. As it is known that only one-half to one-fourth of the water that is actually stored during any one year is run through the canals, the balance being evaporated, and that during cycles of plentiful rainfall, vast quantities of water are wasted on account of the lake not being able to hold it, the parties depending on the Jordan River for supplies have become aroused to the necessity of carrying out some comprehensive plan for the full use of the lake.

SALT LAKE CITY'S EFFORT FOR AN IMPROVEMENT.

In 1882, the corporation of Salt Lake City completed a large canal (the "City Canal") for carrying water from the "Jordan Narrows" to the city, a distance of about 25 miles. This has delivered water for irrigation of trees, lawns and gardens (including some farms) ever since. When the city put in a modern water-works system, some eight or ten years later, it secured the right to 83% of the water of one of the mountain streams nearby, by agreeing to deliver an equivalent amount of Utah Lake water to the owners through its canal. This principle of exchange of the lake water (unfit for domestic use, but excellent for irrigation) for a like amount of potable water will likely form the key to the solution of the problem of an enlarged supply for the city. Other and larger streams of pure mountain water are within reach of the city, to purchase the rights to which would cost large sums of money, as it would almost mean the abandonment of thousands of acres of highly improved farming land on which the water is used at present. But by securing a larger and more certain supply of the Utah Lake water, which it can probably exchange for water from one of the mountain streams, it is believed that the city can provide for a population of 200,000, or even 300,000.

The first active steps toward making a real reservoir of Utah Lake were taken by the city in January, 1900. Through the efforts of Mr. Frank C. Kelsey, then city engineer, who had long advocated a development of the Utah Lake water supply, filings for appropriation and storage of the surplus waters entering the lake were made. These were at once followed by a survey of a high-water line 5 ft. above the compromise level, and application made to the Secretary of the Interior for a right of way over the public lands for the proposed raise in the lake's surface. In the spring, very thorough surveys were made of a water line at the compromise level and of another water line 2 ft. higher.

Surveys were also made for a levee by which an enormous body of shallow water and marsh at the east side of the lake, amounting to one-twelfth of its area, could be cut off and thus the great loss by evaporation from its surface avoided. Regular measurements of the variations in the lake's level were instituted. Surveys and cross-sections of the Jordan River were made, and an extensive series of measurements of the flow in the river and the canals and ditches taking water from it was carried on.

The plan proposed by Mr. Kelsey for securing a full use of the lake water provided for drawing it down to a much lower level during the summer than has been hitherto done, as well as raising it during the winter and spring. To effect the lowering would require an extensive dredging of the Jordan River. This stream has some bars near its head, and some toward the lower end, between the lake and the dam, which nearly stop the flow of water at the low-water mark.

The bottom of the proposed channel has an elevation of 4,507.5 at the lake. The intention is to draw the lake down to 1.5 ft. below low water, or to 4,511 elevation, thus leaving a minimum depth of 3.5 ft., at which the discharge would be over 200 sec.-ft.

The channel proposed for the greater part of the first four or five miles from the lake would be entirely new, cutting across the numerous bends of the river and securing the shortest and most direct route. Below here, where the river is confined between high bench lands, the new work would be mostly in widening, deepening and straightening the present channel.

The new channel, for the first 4¼ miles, would have a bottom width of 100 ft. and side slopes of 1½ horizontal to 1 vertical, with grade of .00217%. North of this, where the ground is not so easily scoured or caved in, the bottom width would be 80 ft. and the side slopes 1 to 1, with grade of .0034%. There would be only 1 ft. fall in the entire length of new channel of 7⅛ miles to the old dam. A rate of fall (1 in 40,000) not exceeding this is used in the earth sections of the Chicago drainage canal, though there the depth of water is much greater. When drawing from the compromise level (8.3 ft. depth), the proposed channel would carry between 700 and 800 sec.-ft. The present channel carries but about 500 sec-ft. at compromise level, and only 60 or 70 at low-water level. Of course, if the canals had been built a few feet lower in elevation in the first place, there would be no difficulty in securing a suitable fall for the new channel.

Owing to the shallowness of the water in the lake at the outlet of the river, it would be necessary to dredge a channel out from the shore for about one-third mile to secure sufficient depth. Nearly 1,000,000 cu. yds. of material would have to be moved in building the new channel. Most of this would have to be done with a dredge, though much of the entirely new channel could be excavated by team and scraper.

A definite location was made of the projected line, and cross-section stakes were set for construction. During the season of 1900, the city spent about $19,000 in surveys, making good its appropriations, and in actual construction work on the proposed new channel from Utah Lake. Since then, the project seems to have been abandoned, at least for the time being, by the city government.

THE INSTALLATION OF A PUMPING PLANT.

The seasons of 1900, 1901 and 1902 were uncommonly dry. The irrigation season of 1900 was started with the lake level 5 ins. below compromise. During the summer and fall, it was drawn down to within 3 ins. of low-water level. The light precipitation of the following winter resulted in the lake being 13½ ins. below compromise at beginning of the season of 1901. The marked shortage of water that season caused the failure of most of the crops under the canals from the Jordan, and after a third dry winter, the farmers found themselves at the beginning of the season of 1902, with the lake 21 ins. below compromise, something that had not been approached since 1889.

FIG. 2. VIEW ON JORDAN RIVER, OUTLET OF UTAH LAKE.

FIG. 3. "THE NEW DAM," ON THE JORDAN RIVER.

It was now resolved by three of the principal canal companies to utilize a portion of the hitherto unavailable supply of water in the lake by pumping it out. As stated before, the bed of the Jordan River is too high to admit of the water in the lake being drained out below a certain level. By pumping it into the head of the river, however, the flow in the latter can be maintained.

A pumping plant was built under control of a Board of Canal Presidents, representing the Utah & Salt Lake Canal Co., the East Jordan Irrigation Co. and the South Jordan Canal Co., on the canals of which over 30,000 acres of land are dependent for water. Plans were supplied and the work carried out under supervision of Mr. Frank C. Kelsey, the engineer of the board. A contract was let to Messrs. Gardner & Ingalls, of Lehi, Utah, for supplying and installing all the machinery needed for pumping by electric power.

The pumping plant is located on the river immediately adjacent to the outlet from the lake. A pile and timber dam was here built across the channel (which is a cut made across a large bend, as part of the proposed dredged channel). The pumps and motors were placed on pile and concrete foundations at the east end of this, and were housed over.

The dam was made by first driving 5 rows of piles, spaced 9 ft. c. to c., in the bottom of the channel. On this was erected the superstructure for the regulating gates. There are nine of these

gates, each with a clear opening of 8 ft. and a lift of 6 ft. They are raised and lowered by means of screw-stems with hand-wheels. These gates prevent the water from flowing back into the lake after being pumped to a higher level in the river; they can also be lifted to allow the natural flow to pass through. A supply of 400 sec.-ft. pumped into the present river channel will raise the level there to ½-ft. below compromise level of the lake.

The plant consists of four centrifugal pumps, on horizontal shafts, each connected by a belt with a 100-HP., Type C, 60-cycle Westinghouse induction electric motor. The pumps are double-suction, with 30-in. inlets and a 40-in. discharge. The vane-wheel, or runner, of each pump is about 42 ins. in diameter, and the extreme diameter of its casing is 9 ft. 4 ins. The pulley directly attached to each pump is 6 ft. diameter. The pulleys on the motors are 22½ ins. diameter. The normal speed of the motors being 580 revs. per min., these pulleys give speeds of approximately 180 revs. per min.

The contract requirements of the plant were as follows, the electric power to be measured after leaving the transformers:

Capacity of 400 sec.-ft. with 2½ ft. lift....30% efficiency.
Capacity of 400 sec.-ft. with 5 ft. lift.....40% efficiency.

This, of course, includes all losses in the station wiring, motors, belting, pumps and friction in pumps and their connecting pipes.

Electric current for the motors is supplied from the Salt Lake City Water & Electrical Power Co.'s plant in the Jordan Narrows (See Eng. News, April 28, 1898). The transmission line to the Mercur mining camp, 21 miles to the southwest of the plant, is tapped at the point nearest to the pumping plant, by a branch line about 7 miles long. This carries a 3-phase current, on three No. 6 copper wires. The total length of transmission is 12 miles. The current is transformed at the pumping plant, from 16,000 volts to 440 volts, by passing through three 170-KW. transformers.

An unusual feature of the operation of this system is the dependence of the power plant in the Jordan Narrows, upon water pumped by power supplied by itself, for a supply of water to make its own running possible. The shortage of water the past two or three years has prevented the plant from running at anything like its full capacity, and at times it has been unable to run at all. The water pumped into the river at the lake enabled it to continue during the fall of 1902, supplying power for the pumping and, to a limited extent, to its customers, when otherwise it would have been obliged to remain shut down. A fatal weakness, however, exists in this system of "perpetual motion," from the fact that, if the plant be shut down, it lacks the supply to start again, so that things come to a standstill. The shortage of water should, and may, be remedied by the installation of an auxiliary steam plant to supplement or replace the uncertain water supply at the power plant. The inability to start up exists only when the lake is extremely low.

At the pumping plant there are also one No. 4 centrifugal pump, for general purposes, and one 3-HP. motor and a vacuum pump, for use in priming the large pumps when ready to start up. From the guaranteed efficiencies, each pump, when running at its normal capacity, is supposed to lift 100 sec.-ft. of water 2.7 ft. with a supply of 100 HP. A test of the pumps showed that they came well within the contract requirements. The pumps were manufactured by the Byron Jackson Machine Works of San Francisco. Notwithstanding the fact that special designs and patterns were necessary because of the great size and low lift of the pumps, they were ordered, built, delivered and two of them installed ready for use within 53 days of the signing of the contract.

The first two pumps were put in operation on August 10, 1902. This was too late for supplying water to any but late crops and orchards, but the plant well demonstrated its value for these. The lake was steadily lowered by the pumping and evaporation, until, when this ceased early in November, it was 0.8-ft. below the low-water mark.

Owing to the irrigation season being well advanced when the pumps were ordered, and the necessity of a short time limit, it was found impossible to stipulate a high efficiency, and the seemingly extremely low figures before named were finally accepted. Though these pumps are fairly good, more efficient ones could have been secured if time had permitted the advertising for bids and the manufacture of the pumps under rigid specifications. Among other things, the size would probably have been 44 ins. instead of 40 ins., permitting a reduction of velocity of discharge from 11½ ft. to 9½ ft. per sec. The extremely low lift required and the great diameter of the pumps presented very unusual conditions. As the water is whirled in a spiral 9 ft. in extreme dimensions, part of it rises much higher in the wheel than where discharged. The top of the runner is even with the level of the discharge water in the river. No longer pipes are used than necessary to reach well down into the water of the lake on the suction side of the pumps, and to reach to the bulkhead next to the river on the discharge side. The main suction pipe and the discharge pipe are each 48 ins. diameter at their outer ends.

For the same reason, the best arrangements for securing electrical power could not be made. The transmission line to Mercur from the Provo Canyon plant of the Telluride Power Co. passes directly by the pumping plant. Owing to the fact that four or five months' time would be required to manufacture and deliver the transformers for transforming the high voltage (40,000 volts) used on this line, it was impracticable to arrange for securing power from this source. Power can also be supplied from the system of the Utah County Light & Power Co. (Eng. News, April 17, 1902), by an extension of its high-pressure line from its substation at American Fork. This would require a line about six miles long. It is probable that a change will be made, whereby the pumping plant will secure its power from one of these two sources.

The real use of this pumping plant, which by many is regarded as but a temporary expedient, is the drawing off of a portion of the lake's volume that would be unavailable without it except by a radical dredging of the river. This, of course, will have to be replaced between irrigation seasons. An important consideration is also the reduction of the area exposed to evaporation. During a year or cycle of years when the precipitation is equal to or above the normal, it is intended to raise the lake during the winter as high as allowable. During the irrigation season the water will then have a natural flow through the regulating gates, no pumping being needed. The enlarged capacity will take care of the feed to the lake during a single wet season, so that not so much water will have to be wasted.

The entire cost of the pumping plant and appurtenances, so far, has been about $50,000. Of this the pumps and motors and their connections, all in place, cost $30,028. Further improvements are being made at and near the plant, which will bring the total cost to about $65,000. Among these is the dredging of a channel out into the lake, excavated to 5 ft. below low water mark. This will permit of an abundant supply of water to the pumps when the surface is still 2 ft. below low water level.

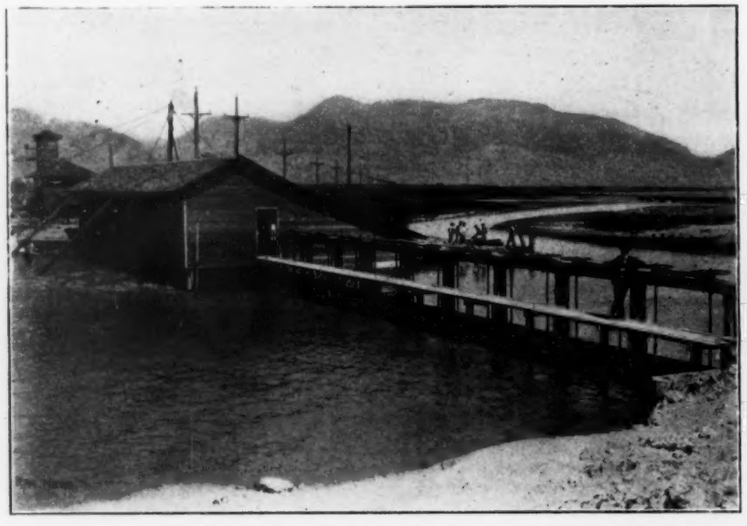


FIG. 4. GENERAL VIEW OF DAM AND PUMPING PLANT AT OUTLET OF UTAH LAKE.

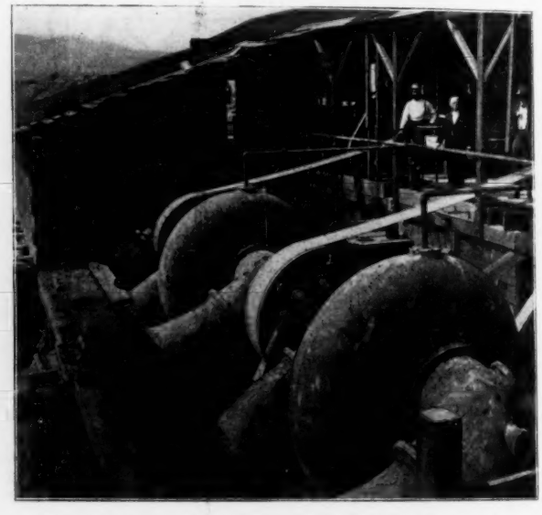


FIG. 5. CENTRIFUGAL PUMPS AT UTAH LAKE PUMPING PLANT.

Of the three plans proposed for keeping this channel free from drifting sand, the one calling for a submerged wooden flume, or box culvert, will likely be adopted. This will have gates at the outer end, to prevent sand from washing in when water is not being drawn through the flume.

POSSIBILITIES OF UTAH LAKE AS A RESERVOIR.

The following table gives the areas and available storage capacities of the lake at different levels:

	Area in acres.	Capacity in acre-feet. Intermediate.	Total.
1.5 ft. below low water	83,400	.....	.....
At low water*	86,400	127,350	127,350
At compromise	93,600	296,000	423,350
2 ft. above compromise	98,000	191,000	614,350
5 ft. above compromise	108,000	309,000	923,350

*3.3 ft. below compromise.

For years of normal precipitation, it is a con-

servative statement that 30 per cent. of the total rainfall over the lake's watershed, or 672,000 acre-feet, will reach the lake. What the evaporation from the lake is, it is impossible to say, but evaporation test made elsewhere by the U. S. Signal Service would seem to place it at about 4½ ft. per year. Assuming that the lake's surface has been drawn down to 1.5 ft. below low water mark at the end of the irrigation season, the inflow for a year following (with average rainfall) should raise it to 2.6 ft. above compromise, a rise of 7.4 ft. Evaporation within the same time would reduce it by 4.5 feet, so that there would be a net gain (available for use) of 2.9 ft. This depth, over the area at compromise level, would furnish 270,000 acre-feet available for irrigation. For the irrigation season of 150 days, beginning May 1st, this will furnish a daily supply of 1,800 acre-feet, or a continuous flow of 900 sec.-feet.

For the river in its present condition to carry this amount, would necessitate starting the pumps when the lake was still over a foot above compromise. By dredging out the higher places in the river bed, and straightening out and widening a few of the worst places, it would easily carry the above amount of water till the compromise level was reached before starting pumping. But the latter will be entirely done away with by the radical lowering of the channel involved in the full utilization of the lake.

The supply of 270,000 acre-feet will well irrigate 67,250 acres, allowing 4 ft. in depth applied to the lands during the irrigation season. This will allow of the reclamation of 22,500 acres of new land, besides furnishing the 45,000 acres that are already under ditch but have an uncertain supply.

The 4-ft. depth of water is perhaps more than is usually applied, though experience shows that, with the wasteful methods that are still in use in Utah, as well as elsewhere, ordinary crops will not do their best if nearly this amount of water is not available for them. The future should much improve this showing. The low duty of 75 acres per second-foot for 150 days is allowed with this aggregate supply. The supply for the 60 to 90 days of most active irrigation is larger than indicated by this, and is less for the remainder of the season. The higher level of the lake during the earlier half of the season allows of a liberal supply of water when it is most needed.

At the east side of the lake is an area of shallow water and marsh, separated for the most part from the main body by a long, narrow strip of low land, called "Snail Island." This and a spit from the south shore form an almost continuous natural dyke for about 5 miles, north and south This area, which is called "Provo Bay," greatly increases the evaporation from the lake. The plan of full use of the lake's supply will include the building of a dyke or levee along this raised ground, thereby not allowing the lake to spread out over the marshes of Provo Bay. The enormous evaporation from this body of shallow water, amounting to between 7,000 and 8,000 acres at normal stages, will then be saved. The necessity for lessening the area of the lake, and at the same time increasing its depth, is fully recognized. During the year 1900 there was actually used from the lake for irrigation purposes only 89,000 acre-feet, about one-half the quantity needed by the lands, and representing only about one foot in depth on the lake.

The segregation of the area in Provo Bay, by avoiding the evaporation of 4½ (perhaps 6 or 7) ft. from the shallow water, would save nearly one-half the quantity used in 1900. The land thus cut off from the lake can be reclaimed and made valuable for farming purposes. The most effective manner of doing this is by collecting the drainage on to it in sumps at the lowest places next to the dykes and pumping it into the lake. It can be done by gravity (but much less thoroughly), by constructing intercepting ditches back far enough on the light slope to enable them to discharge above the high water level of the lake at points where higher land approaches the latter.

A scheme of land reclamation will eventually follow the development of the lake as a reservoir. The bottom of the lake, where shallow, can be dredged for material to fill in the adjacent low marsh lands, thus improving both at the same time. The unhealthful conditions caused by the annual rise and fall of the lake over these lands will also be done away with.

The building of secure dykes is much more difficult than generally supposed, on account of the high waves caused by the winds having such a free sweep over the lake's expanse, and also from floe-ice, that is sometimes swept in and heaped up on the shore in grinding masses over 20 ft. high by the winds, after the ice breaks up in the spring. For this reason, it is doubtful if any but the Snail Island dyke will be built for a long time to come. A large area of shallow water can be cut off from the extreme south end of the lake by a dyke across its narrowest point, but this will have to be entirely artificial.

Utah Lake promises to be the first object of help extended under the provisions of the recent Act of Congress, whereby the income from the sale of public lands in the respective states of the arid region can be applied to the construction of irrigation systems in those states. The values in water rights and farms that can be created by carrying out a comprehensive plan for the use of Utah Lake, it is difficult to estimate closely, but they will run into several millions of dollars. What the cost of this would be it is impossible to say; probably not less than $1,500,000 when the enlargement of existing canals is included.

Investigations have been carried on with a view to the diversion of the waters of the Du Chesne River, and other large streams of the Uintah Indian Reservation on the east side of the mountains, into the Utah Lake watershed. This would greatly increase the supply available for storage.

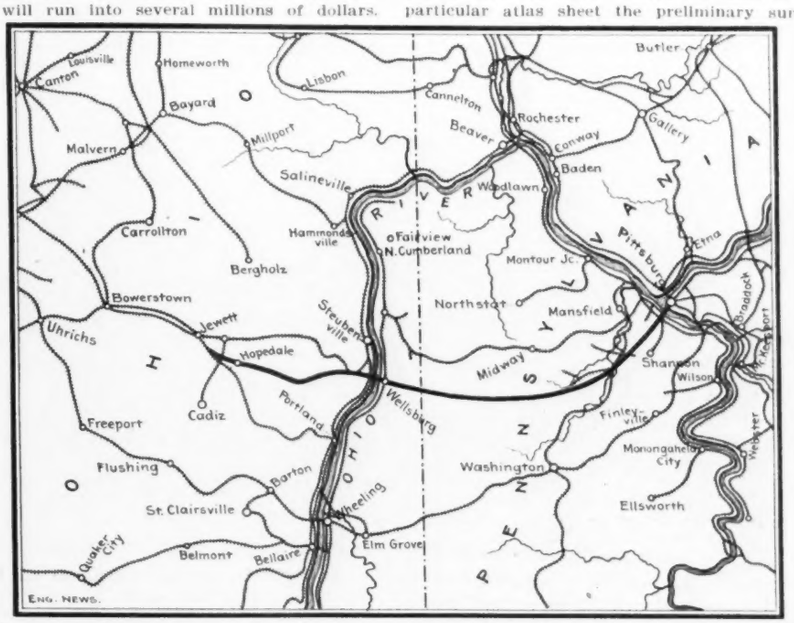


FIG. 1. MAP SHOWING GENERAL LOCATION OF THE PITTSBURG, CARNEGIE & WESTERN R. R.

LOCATION AND CONSTRUCTION OF THE OHIO RESIDENCY, PITTSBURG, CARNEGIE & WESTERN R. R.

Probably few of our readers are aware that there is to-day in process of construction a railway upon which more money is being expended per mile of grading than has ever been expended upon any line of equal length in the United States. There is one 60-ft. fill, for example, that will require a million cubic yards of earth in a distance of less than 3,500 ft.

We shall first describe some engineering features involved in the location of this remarkable line, and shall then describe briefly the methods used by the contractors in construction, giving costs of doing certain kinds of work.

LOCATION.—The Pittsburg, Carnegie & Western R. R. is the name of this new railway line, some 60 miles in length, extending from Pittsburg, Pa., westward until it connects with the Wheeling & Lake Erie R. R., of the Wabash system near Jewett, Ohio, as shown in Fig. 1.

The Western or Ohio Residency of this line is chartered in Ohio as The Pittsburg, Toledo & Western Railroad Company, is about 20 miles long and includes the bridge over the Ohio River, near Mingo Junction, four miles below Steubenville, Ohio. It is this part of the line that we shall describe.

As shown on the profile, Fig. 2, it is evident that no attempt has been made to secure a cheap line by following the sinuosities of the valley, but the road springs from one hill to the next, cutting across or tunneling projecting hog-backs and riding over valleys on fills of 40 ft. or more. In this short distance there are eight long tunnels, and an equal number of 50-ft. span concrete arches under high fills. The maximum gradient is 0.7%; and the maximum curvature is 3°. Only 56% of the whole line is on tangents, and of the curved distance one-quarter is on lighter than 2° curves. There are no grade crossings of highways.

USE OF U. S. GEOLOGICAL MAP.—Perhaps the most instructive location problem solved in this work was one involving the use of an atlas sheet of the U. S. Geological Survey with a contour interval of 20 ft. Before the issue of this particular atlas sheet the preliminary surveys and first location of the proposed line had been completed, and work was about to begin when a new resident engineer, Mr. T. H. Loomis, was appointed. Happening to be personally acquainted with the Government topographer, Mr. W. T. Griswold, who was then engaged in mapping this part of Ohio, Mr. Loomis secured from him a photograph of the contour map then almost finished. From this photographic copy Mr. Loomis projected a new location between stas. 650 and 836, effecting thereby a saving of 2,200 ft. in distance and 75° of curvature, besides eliminating 600 ft. of tunnel. This change measured in dollars and cents resulted in reducing the first cost of that portion of the road by at least $85,000. Turning to the last annual report of Charles D. Walcott, Director U. S. Geological Survey, we find that 1,864 sq. miles of the State of Ohio have been mapped thus far, at a cost of $12,000; yet one small atlas sheet, covering some 220 sq. miles, has been the means of saving a sum more than seven times what it has cost to map the whole 1,864 sq. miles. As a tribute to the accuracy of the Government topographer, Mr. Griswold, it may be well to add that when the railway engineers ran their profile levels along the paper-projected line, at no place did the actual elevation differ more than 16 ft. from the elevation scaled off the contour map. To any engineer ac-

quainted with the roughness of eastern Ohio and with the approximate methods necessarily employed in Government topographical surveys of such vast areas, these figures speak forcibly enough. And it is well that just such facts as these should become generally known, for there has been altogether too great an apathy in the past in furthering the work of the U. S. Geological Survey—a work that is destined to be of incalculable value to every citizen of the United States.

Just why or how it happened that the first engineering parties overlooked this better route is hard to tell. We may hazard this guess, however: At the place where the change was subsequently made there was a long upgrade of 0.7% on the first location. Since this was the maximum grade permissible it would naturally appear that any saving in distance would be out of the question, since to do so would increase the gradient. But when the proposed new line was actually projected upon the Government atlas sheet, and studied in connection with the original location profile it was seen that by going back far enough a section of line having less than 0.7% grade could be increased to 0.7%, thus enabling the line to be shortened farther on at the critical place, without exceeding the maximum grade.

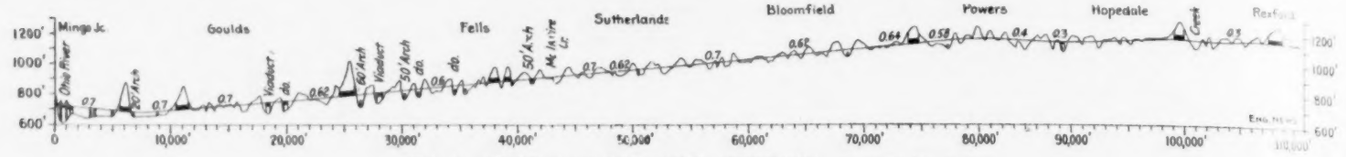


FIG. 2. PROFILE OF THE OHIO RESIDENCY, P., C. & W. R. R.

CONCRETE CULVERTS.—As above stated there are eight large concrete culverts each having a span of 50 ft., and the largest having a "barrel" 180 ft. long, thus making 13,000 cu. yds. of concrete in a single culvert. Fig. 3 shows a graduation plan of one of these culverts, and Fig. 4 shows a profile of the creek crossing with a cross-section of the culvert. It will be noted that inside this particular culvert there is a retaining wall and a 14-ft. wagon roadway, so that the culvert serves not only to carry the water, but acts as a tunnel for a wagon road. Fig. 5 shows the centers of one of these culverts in process of construction, and a temporary construction trestle passing across the culvert. All cement used in concrete work is carefully tested by the engineers in the company's laboratory at Mingo Junction, as is also the sand used by the contractors. It is exceedingly difficult to find good sand along the line of the work. That which is used is generally dug out of small pockets along the creek bed and screened, but even then it is quite loamy. To reduce the percentage of loam the engineers require all the stone dust and fine screenings from the stone crushers shall be mixed with the creek sand in proportions of 1 of creek sand to 1 or 2 of crusher sand. Laboratory tests have shown that by washing out the 10% of loam contained in the creek sand the tensile strength of the mortar is reduced in a marked degree. It has also been found that this mixed creek and crusher sand gives somewhat better results than the generally approved river sands.

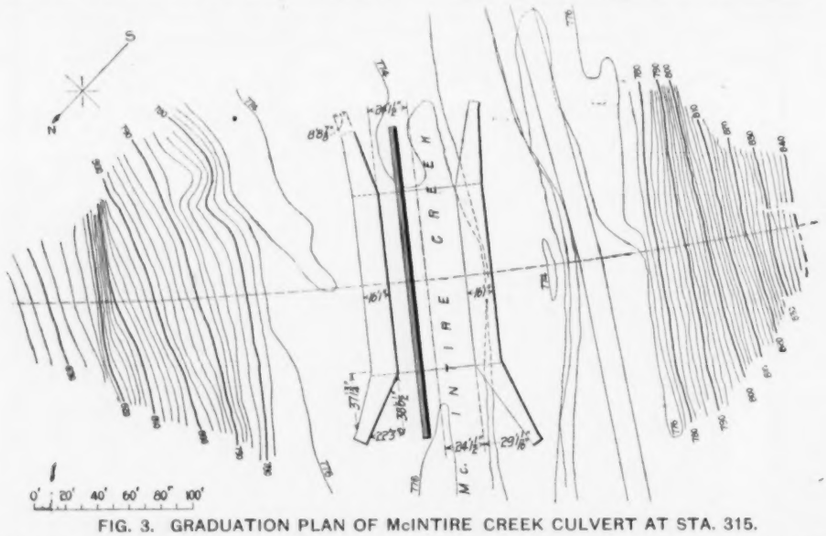


FIG. 3. GRADUATION PLAN OF McINTIRE CREEK CULVERT AT STA. 315.

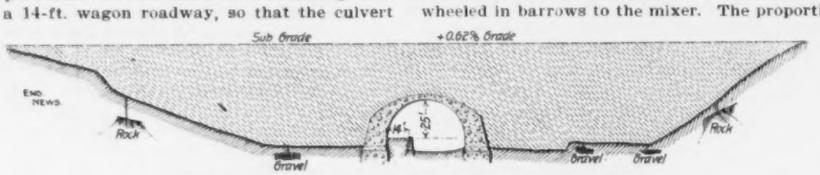


FIG. 4. PROFILE OF McINTIRE CREEK CROSSING.

COST OF MAKING CONCRETE.—Most of the contractors use mechanical concrete mixers run in conjunction with their crushing plants.

One contractor using a ⅞-cu. yd. cubical mixer averaged 40 cu. yds. of concrete per 10-hour day with the following force:

1 foreman;
3 men loading barrows and feeding mixer;
1 man attending to engine of mixer;
2 men loading barrows with concrete;
4 " wheeling concrete barrows, 100-ft. haul;
4 " ramming concrete;
4 " wheeling in and bedding large stones in concrete.

Wages of all these men, except the engineer, are $1.50 per day each. The plant is located on a hillside with the crusher bins above the loading floor or platform that extends over the top of the mixer, so that crushed stone can be drawn directly from the chutes of the bins and wheeled to the mixer. The sand is hauled up an incline in one-horse carts and dumped on this floor, and is also wheeled in barrows to the mixer. The proportions of ingredients used were 4 bags of cement, 4 barrows of sand and stone dust, and 7 barrows of crushed stone. The cost of ramming, it will be noted, is much larger than is ordinarily the case.

Another cubical mixer, not in operation when a member of our editorial staff visited the work, was so arranged as to dump the mixed concrete directly into wooden skips which were run under the mixer on trucks. There were two skips, each holding 1 cu. yd., and one truck running on light rails. A mule is used to pull the loaded skip on the truck over to a 60-ft. boom derrick operated by an engine. This derrick then picks the skip up, swings it over to the concrete wall where it is dumped.

Another contractor had just installed a small Smith Conical Concrete Mixer. Each charge was a small one—4 barrows of stone, 2 barrows of sand and 2 bags of cement—and the mixer is so designed that a low loading platform can be used which is decidedly advantageous where the stone and sand must be wheeled up on to the loading platform. The cubical mixers have a loading platform 8 to 11 ft. above the ground level. This conical mixer has its loading floor only 4 ft. above the ground level, but it is only fair to add that the mixer is so arranged as to dump its charge into a sort of sump or hole about 3 ft. deep. Into this sump a derrick delivers iron skips which receive the charge of mixed concrete. These skips or buckets are then swung out and dumped in the work. The force employed on this mixer was:

1 man feeding mixer;
1 man running the mixer engine;
1 derrick engineman;
2 tagmen swinging derrick boom and dumping buckets;
6 barrowmen wheeling stone and sand to mixer;
2 men tamping concrete.

The output of this gang was said to be 50 cu yds. per day of 10 hours, and a short time observation confirmed this statement.

At another culvert the contractor was mixing concrete by hand and claimed that he was doing the work as cheaply as with a mixer, considering moving of plant and depreciation. He had 20 men working in two gangs of 10 in a gang, each gang being served by a derrick operated by an engine. The daily output of these 20 men was 60 cu. yds. of concrete rammed in place. The men were Italians working for $1.50 per 10-hour day. Each Italian cooks his own food, and the storekeeper said that $4 a month would cover the cost of all food eaten by each man.

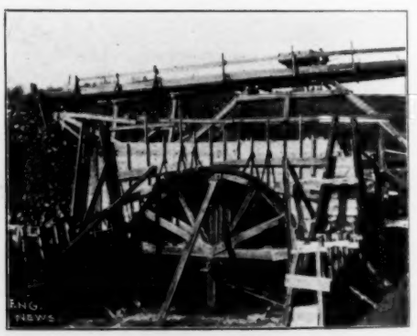


Fig. 5. Concrete Arch, 50-Ft. Span, and Construction Trestle.

Notwithstanding their princely income—princely compared with the cost of living—the men had struck several times on slight provocation. In one instance a strike followed because a man who had been ramming concrete was ordered to shovel earth. He was above such work, and his "gang" sustained him in his contention. The contractor, a man who had seen strikes before, arrived and ordered the fellow to resume his concrete ramming—loudly proclaiming that the man was right in his demands. A day or two later this fellow was "promoted" to another job up the creek, and was there put to shoveling sand out of the creek bed in water up to his ankles. When

he struck—this time for good—he had no "buddies" to join him.

Italian workmen form "unions" among themselves. If one goes forcibly, all go. But if one leaves of his own free will for another part of the work, he leaves the "union" and must look out for himself thereafter.

COST OF STEAM SHOVEL WORK.—The cuts and fills are so large that steam shovels are used

Fig. 6. Typical Construction Trestle, P., C. & W. R. R.

for most of the work, although a good deal of earth has been moved with wheel scrapers at the beginning of cuts where hauls are short. Small traction shovels weighing 35 tons and large railroad shovels weighing 65 tons are to be found on adjoining sections, the kind of shovel used evidently depending upon what the contractor already had on hand.

As showing very clearly that these larger shovels are adapted best to heavy continuous work with few long moves, the following data are instructive:

A 65-ton Bucyrus shovel was moved 1½ miles, one mile of which was over a rough country road and the last half mile across a field having a 15° up hill slope. The time occupied was 8 days costing $316 distributed thus:

Steam shovel crew	8 days.	$160.00
Foreman at $3.50	8 "	28.00
Eight men at $1.50	8 "	96.00
One team at $4.00	8 "	32.00
Total		$316.00

This is equivalent to a cost of $210 per mile moved.

At another time it took 30 days to move this same shovel 6 miles, and at still another time it took 23 days to move ¼ mile from one hill down across a valley to the next hill, at an expense as above given of about $40 a day while engaged in moving.

Compare with this the cost of moving a 35-ton

Fig. 8. Tunnel Portal, Showing Loading Platform.

Vulcan traction shovel over 18 miles of rough road, the last mile or so being across fields and up a steep hill. The crew was engaged 18 days at a cost of $35 a day, which is equivalent to $35 a mile moved.

It is quite evident that these smaller shovels with 1 cu. yd. dippers are greatly to be preferred where cuts are light and moving frequent, since they can be moved in days where it takes weeks to move the larger shovels.

As showing the efficiency of these 35-ton traction shovels the following will be of interest:

Shovel No. 1.—1-cu. yd. dipper, 11 mins. loading 6 dump cars of 3 cu. yds. nominal capacity each, 6 mins. waiting for contractor's locomotive to haul the train 800 ft. to the dump and return. Dumping one car at a time through a trestle takes 3 men 3 mins. to dump the train of 6 cars; the locomotive therefore travels the 1,600 ft. in 3 mins., going up an 8 or 10% grade on the return trip with the empty cars. The rails are light 35-lb. rails laid on 6 × 6-in. × 5-ft. ties spaced about 4 ft. c to c. Dumping is done through a trestle shown in Fig. 6. The bents of this particular trestle are 40 ft. high. The trestle is of round timbers and is of course left in the embankment. The force employed on this shovel was:

1 boss;	1 engineman on water supply pump;
1 cranesman;	
1 engineman on shovel;	3 pitmen;
1 fireman;	6 drillers;
1 locomotive engineman;	1 blacksmith;
1 brakeman on train;	2 dumpmen.

This crew averaged 500 cu. yds. excavated per 10-hour day. The material being mostly a soft shale. The drillers working with churn drills put down holes about 15 ft. deep. A squib of 1½ sticks of dynamite is fired in each hole to make a chamber to receive the black powder used in shattering the shale. About four of these holes are fired each day, using 3 cans of powder of 25 lbs. each in each hole. The face against which the dipper worked was in some cases only 10 ft., in others 15 ft. high.

It will be noted that the shovel is apparently

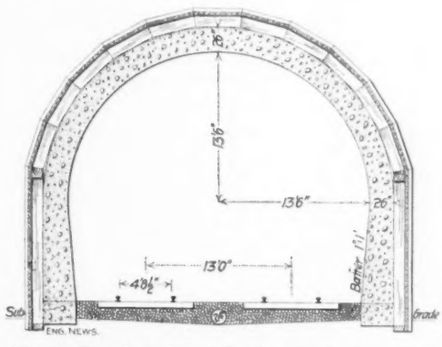


Fig. 7. Standard Tunnel Section, P., C. & W. R. R.

idle one-third of the time. As a matter of fact there is not as much lost time as appears, for during the absence of the cars the shovel is moved forward, and as it takes about 3 mins. to move forward 4 ft. and block up, it will be seen that with a shallow face much time is necessarily consumed in this way. The shovel consumes 28 bushels of coal, and the locomotive 7 bushels per day.

Another contractor instead of using a locomotive uses a hoisting engine which hauls 4 dump cars by means of a cable. Dump cars weighing 2,500 lbs. each empty and holding 3 cu. yds. of loose earth are used. The hoisting engine is stationed on the bank above and in front of the shovel, and as the shovel advances must be shifted from time to time. The cars coast down to the dump by gravity, and a team hauls them a short distance to the trestle. There was only one train of these cars in use, and as a consequence a great deal of valuable time was lost that might have been saved by using a double drum engine, two cables, two trains of cars and a switch track. The foreman was well aware of this, but he simply didn't have at that time the full plant needed.

Another contractor was using two hoisting engines and cables, one engine located above the shovel, the other engine down the hill, half way to the dump. This was done not only because the distance to the dump was long, 1,600 ft. or thereabouts, but because the cut was on a curve, and a long cable would consequently strike the sides of the cut. Even as it was, snubbing posts were set upright at intervals to guide the cable approximately along the line of the track. Two trains of 4 cars in a train were operated, so the shovel was kept busy. It takes about 2 mins. to get the loaded train out of the way and the empty train up into its place ready to be loaded.

One of the large 65-ton shovels was operating at great disadvantage because only one train of 6 cars and a locomotive was provided to carry away the material. This shovel would load the 6 cars in 5 mins., then lie idle 10 mins. waiting for the train to go to the dump and return! As a result, the output of this big shovel was actually less than that of a small shovel in similar material, without considering the time consumed in moving it from cut to cut.

One of the dangers that a contractor risks in this work is the danger of a "slip" that will bury his shovel. There are seams of very slippery clay in the shale, and in one case a contractor

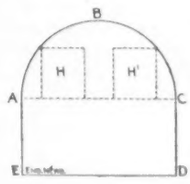


Fig. 9. Double-Heading Method of Attack.

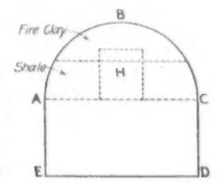


Fig. 10. Single-Heading Method of Attack.

barely got his shovel back in time to escape burial at the entrance to one of the tunnels. Like the frog that jumped up one foot during the day and slipped back two at night, this contractor now finds himself 300 ft. farther away from the tunnel portal than he was last Thanksgiving.

As a means of encouraging keener competition among contractors in pushing their work, the Resident Engineer intends adopting the policy of sending a copy of weekly progress on all sections to each contractor, so that it may readily be seen "who is getting there and who isn't." This practice has proved successful elsewhere and should prove equally so here.

TUNNEL WORK.—Fig. 7 shows the standard double track tunnel section used on the Pittsburg, Toledo & Western R. R. Fig. 9 shows one of the methods of attack in excavating the tunnel. Two 7 × 8-ft. headings, H and H', are driven at the same time, the floor of the heading being about 12½ ft. above subgrade. Then as these headings advance the material between them is drilled and blasted out. After the semicircular segment, A B C, of the tunnel is removed in this way, clear through from portal to portal, the 12½-ft. bench, A C D E, is taken out.

Another method of attack is shown in Fig. 10, where a single 7 × 8-ft. heading, H, is run in the center of the upper segment of the tunnel. This method is slower than that of Fig. 9, and except in very easily drilled material is not in favor with

Fig. 11. Culvert with Masonry Walls and Concrete Arch Crown.

the best tunnel men. In the double heading method two steam drills are operated, one in each heading without interference of the two gangs. Moreover there is a rivalry between the two drilling gangs that always works for good.

If a high rate of progress is not essential, the single heading method will effect some saving in the powder bill, for the headings themselves are

the most expensive part of the work in powder consumption.

Fig. 8. shows the portal of one of these tunnels. The excavated material is run out in small dump cars and dumped in a chute that leads to the lower dump car on grade below. The following is the force engaged in tunnel work where hand drills were used:

		Wages per 10-hr. shift.
1	General foreman at $4.00	$4.00
1	Foreman at $3.00	3.00
1	Blacksmith at $3.00	3.00
2	Carpenters, at $3.00	6.00
10	Miners at $2.00	20.00
10	Muckers at $1.50	15.00
1	Team at $4.00	4.00
26	Total	$55.00

The cost of labor and powder in driving 110 ft. of the upper part of this particular tunnel has been $4,500, or $40.90 per lin. ft. which is equivalent to $2.73 per cu. yd. since there are 15 cu. yds.

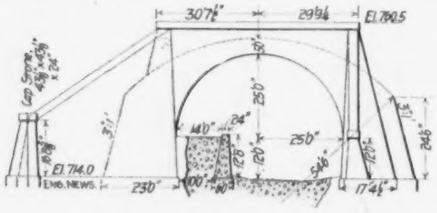


Fig. 12. Elevation of Typical 50-Ft. Concrete Arch.

per lin. ft. As shown in Fig. 10, the upper part of this excavation was in hard fire clay and the lower part in shale. 500 lbs. of dynamite and 400 exploders were consumed in this 110 ft., or less than ⅓-lb. of dynamite per cu. yd. excavated, which shows that the material was easily shattered.

The cost of driving a 7 × 8-ft. heading, H, in sandstone, was $1 per cu. yd. higher than the average cost of the whole section A B C. The cost was as follows:

Labor per shift	$18.00
Explosives	3.84
Repairs	.90
Light	.32
Total	$23.26

Each shift removed 6.2 cu. yds. of heading, making the cost $3.75 per cu. yd.

On another tunnel through sandstone, using power drills, the cost of driving a full-sized heading, 31 ft. 4 ins. between wall-plates, 15 cu. yds. per lin. ft., was as follows per lin. ft. of heading:

Labor	$2,527.45
2,000 lbs. dynamite, 40%, at 12 cts.	240.00
470 gals. kerosene oil, at 12 cts.	56.40
1,875 gals. gasoline, at 12 cts.	225.00
3,000 bu. coal for air compressor, at 9 cts.	270.00
Machine and lub. oil	62.50
Blacksmithing	150.00
41,649 ft., B. M., timber, at $23 per M	957.93
Total cost of 100 lin. ft.	$4,509.28
Cost per lin. ft., including timber	45.09
Cost per cu. yd., including timber	3.06

The timber ribs or rings were of 12 × 12-in. stuff, 4 ft. c. to c., lagged with 4-in plank.

On five different tunnels the average progress during the week ending Feb. 27, was 26 lin. ft. of upper section A B C, Fig. 10, running one 10-hour shift a day. The material in most cases was shale, in some cases sandstone. At the Mount Washington tunnel near Pittsburg, using power drills and the double heading method of attack shown in Fig. 9, the progress is said to be 18 to 20 ft. per week per shift of 26 men. The material is a harder shaley sandstone.

COST OF TUNNEL TIMBERING.—Fig. 7 shows the standard tunnel section and timbering. The timber ribs of 12 × 12-in. Georgia pine are ordinarily spaced 3 ft. c. to c., although in soft material they are placed 2 ft., and in hard material 4 ft. c. to c. In one tunnel the cost of timbering has been as follows:

	Cost per 1,000 ft., B.M.
Georgia pine, f. o. b. cars	$23.60
Hauling, 6 miles	3.00
Cost of framing	5.00
Cost of erecting and bracing	3.00
Total cost in place	$34.60

To put in the packing over the lagging has cost 80 cts. per cu. yd.

Carpenters framing receive $3 per 10-hour day, and laborers erecting $1.50. The framing and erecting have cost $8 per M, it will be noted, but should not have cost to exceed $5.50 per M had there been fewer "bosses" and more workers. This item of "bossing" is one that many a contractor could reduce to advantage by employing a larger force of workers to each foreman, even if as in this case, a lot of timbers were framed far in advance of the progress of the excavation. The hauling item, it will also be observed, was a high one. Over the rough roads in this part of the country, about 1,000 ft. B. M. of pine forms a good load for a team, and where the haul is 6 miles, a round trip of 12 miles a day is all that a team will ordinarily accomplish.

It was noticed that certain contractors had erected small portable saw mills and were felling and sawing the timber near the tunnel work. This is an expedient that contractors in the East do not adopt as often as is done in the far West, and to illustrate what a great saving may often be effected thereby we shall give the cost of sawing with a portable mill used by a member of our editorial staff in the far West. A 20-HP. portable boiler and engine was used to run the portable saw, and 5 men constituted the crew. The output was 8,000 ft. B. M. of heavy timbers per 10-hour day at a cost of $1.25 per M for the labor, so that including a liberal allowance for rental of the plant and for fuel we have a total cost of about $2.50 per M after the timber is delivered at the mill. The cost of cutting and skidding the logs to the mill, which should be close to the forest, is $1 to $1.50 per M with wages of labor at $1.50 a day. The owners of the forest land may charge a "stumpage" of from 50 cts. per M in the far West to $5 per M in certain parts of the East, for pine, $2 is a fair price for a small lot of timber on a farm several miles from railways. It will be seen that long hauls can thus be avoided very often, and timber laid down at the work for less than half the cost of timber brought by rail from a distance.

ENGINEERS AND CONTRACTORS.—We wish especially to acknowledge our indebtedness to Mr. J. W. Patterson, Chief Engineer of the Pittsburg, Toledo and Western R. R. and to Mr. T. H. Loomis, Resident Engineer of the Ohio Residency, for many courtesies extended and for opportunities given to examine the progress of this interesting work, as well as for blue prints from which our cuts have been prepared. We also wish to thank the contractors for statements of progress. The following are the engineers and contractors in charge of and doing the work that we have described:

J. W. Patterson.....Chief Engineer.
Boller & Hodge.....Consulting Engineers.
S. Wimmer.....Supervising Engineer.
C. McK. Watts.....Principal Assistant Engineer.

OHIO RESIDENCY.

T. H. Loomis.....Resident Engineer.
A. B. McGrew.....Division Engineer—Div. 9.
F. W. McElroy.....Division Engineer—Div. 10.
W. A. Hammel.....Division Engineer—Div. 11.
C. F. Guild.....Division Engineer—Div. 12.

CONTRACTORS—OHIO RESIDENCY.

	Section		Section
A. McMullen & Co.*	39	O'Hern & Keefe	47
T. A. Gillespie & Co.†	39	O'Hern & Keefe	48
C. H. Connell Co.	40	Fogle & Francy	49
Fogle & Francy	41	P. Moran Co.	50
W. M. Chisholm	42	Ferguson Contracting Co. (4 sections)	51—54
C. H. Connell Co.	43	Moran & Co.	55
Douglass Bros, Williams Bros. & Morse	44	Moran & Co.	56
Douglass Bros, Williams Bros. & Morse	45	Mathew Spellacy	57
A. H. Jacoby Co.	46	Bothwell & Carson	58
		Rogers & Walker	59

*Bridge masonry. †Trestle.

A NEW SYSTEM OF FINISHING CONCRETE STRUCTURES.

The extending use of concrete for structures in which artistic effect is an important consideration has led to various attempts to improve the appearance of the concrete surface, several of which have been described in our columns. The general subject was discusssed in our issue of July 3, 1902, and we may note particularly subsequent contributions in our issues of July 24 and August 7, 1902, and the recent paper by Mr. Geo. W. Lee, in our issue of March 19. In small park bridges the surface of the concrete has sometimes been concealed by a layer of cobble stones laid against it in cement, and in our issue of Jan. 22 there was described a system of finish in which the cement was brushed off the exposed face when partially set, leaving the stones exposed.

In the new method described below a similar result is aimed at, but with a fine concrete facing which when roughened will give the final surface the texture and appearance of stone. The facing may be applied to the concrete work in construction and subsequently given the necessary treatment, but in most cases slabs or blocks are made, and after being treated at the shop are applied to the main structure, giving the effect of ashlar work of any desired kind of stone.

The method consists in using a facing mortar composed of Portland cement and finely crushed stone, the kind of stone depending upon the appearance desired. Thus any shade of red or grey granite, sandstone, etc., can be obtained, and special effects can be obtained by the use of sand, pigments, etc., in the mixture. This mortar is composed of about 1 part Portland cement to 2 or 3 parts of the finely crushed stone. In casting blocks, the mortar is placed on the bottom of the form or mold to a thickness of about ½-in. to 1 in., and above it is placed the ordinary concrete composed of 1 part Portland cement, 2 parts sand and 4 parts of stone crushed to a size of ¼-in to ¾-in. The facing and the body of the block thus form a solid homogeneous structure when the concrete has set. The finished block has the usual smooth surface, the ramming having flushed the cement to the face of the mold. The exposed surfaces are then treated by chemical or mechanical means to remove the cement matrix at the face, leaving the granular particles of stone partly exposed. In general this is done by washing the surface with a weak acid solution, then with clean water, and finally with an alkaline solution to neutralize any effects of the acid. In the finished work it is difficult to detect that the material is not natural stone, except by close inspection. The stone is crushed to pass through a sieve of 10 to 30 meshes per sq. in., according to the character of finish desired, and enough water is used to make a soft plastic mixture.

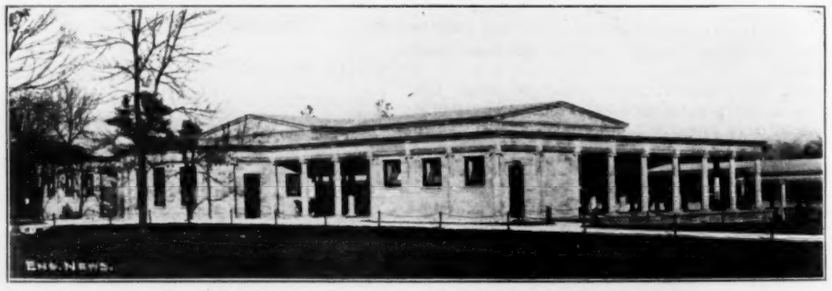


FIG. 1. CONCRETE-FACED BUILDING AT BOAT LANDING; WASHINGTON PARK, CHICAGO.

This system has been used in two ornamental buildings in the Chicago parks. At Washington Park, a boat house and landing, with two long colonnades along the water front, was built last year at a cost of about $25,000. A view of the building is shown in Fig. 1, while Fig. 2 is a plan of the entire structure. The walls are of common brick faced with concrete slabs. In the face mortar of these slabs crushed pink granite was used, so that the building appears to be built of this stone. The numerous columns are hollow, fitted on structural steel columns, and steel beams are used at some of the lintels, etc. In more recent

buildings, however, no metal work is used, the columns are monolithic, and blocks for long spans are strengthened by iron rods embedded in the concrete. The steps and the floors of the colonnades are also of concrete, representing alternate squares of red and grey granite.

The other building is a bathing pavilion in McKinley Park. This is a one-story structure, with toilet rooms, laundry, colonnades, etc., and an open air bathing pool about 130 × 300 ft. This building is also of common brick, with a finish of concrete slabs made from grey granite. All the columns, cornices, moldings, and other architectural and ornamental features are of this material, and the effect is extremely pleasing. One of the features of the system is that owing to the fine crushing of the stone used in the concrete, the ornamental work can be cast so as to appear as sharp and clean as cut stone. This is noticeable in the capitals of columns, the toothed or dentil moldings of cornices, etc. Some of the lintels, sills and other parts are made in blocks 10 ft. long. The columns are single blocks (instead of being built up in sections as in the other building). The wall slabs are 4 ins. thick, attached to the brick backing by cement concrete and wire anchors, embedded in the concrete, and the cornices, etc., have anchors embedded in them as may be required. The cost of the building will be about $35,000.

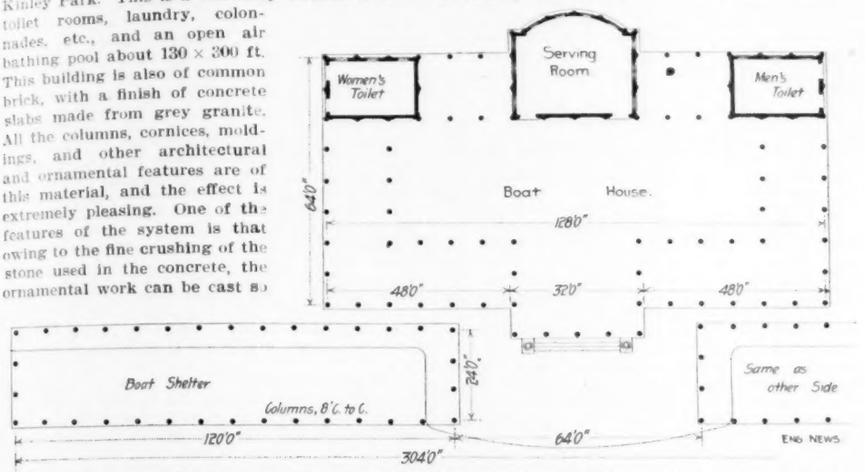


FIG. 2. PLAN OF BOAT LANDING IN WASHINGTON PARK; CHICAGO. (THE ENTIRE STRUCTURE HAS A CONCRETE FACE.)

J. F. Foster, Superintendent of South Park Commission, Chicago. Wm. Black, Engineer, H. S. Richards, Asst. Supt., Joint Inventors of Concrete Face System.

In regard to this building, it may be remarked that an open air bathing pool in a public park is something of a novelty. The park, which has an area of only about 34 acres, is located in one of the poorer districts of the city, at Western Ave. and Archer Ave., near the stock yards, and the bathing facilities are intended for the recreation and sanitation of the people in this neighborhood during the summer. In addition to the main pool, which is 6 ins. to 8 ft. deep, there is a pool 150 × 300 ft., only 24 ins. deep, with a sandy bottom, where children can wade. Fig. 3 is a general plan of the concrete pavilion.

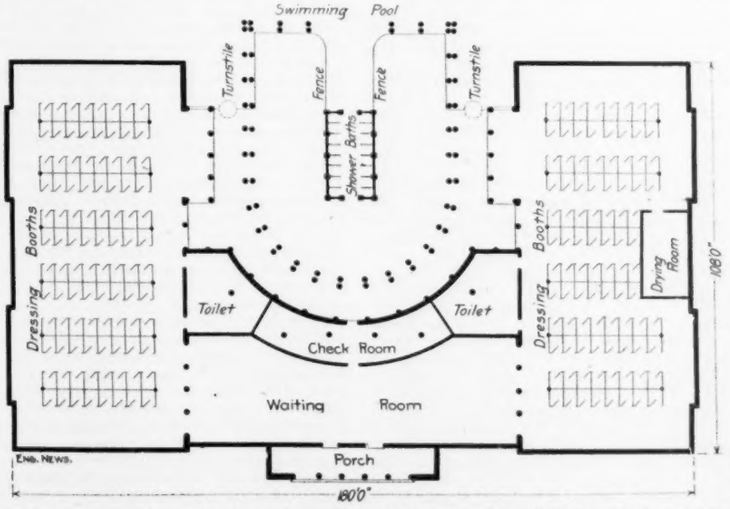


FIG. 3. PLAN OF CONCRETE BATHING PAVILION AT McKINLEY PARK, CHICAGO.

This system of concrete face work is the joint invention of Mr. Wm. Black, Engineer of the South Park Commission, Chicago, and Mr. H. S. Richards, Assistant Superintendent. The invention has been patented by them, the patent covering the obtaining of a natural stone finish for concrete by mechanical, chemical or other means. The tensile and crushing strength of the concrete is not affected by the treatment, as has been shown by numerous tests. The general design of the park buildings above described was made by Mr. J. F. Foster, General Superintendent of the South Park Commission. The methods of construction were designed by Mr. Black, and all the work was done by day labor under the direction of Mr. Richards. The cost was at least 50% less than for Bedford stone, and almost as cheap as for good brick. It is expected that this year a concrete-steel bridge will be built in one of the parks, and faced with concrete slabs to resemble ashlar granite masonry.

AN ADDRESS TO ENGINEERING STUDENTS.*

In the old days when I was a student—something more than a quarter of a century ago—the general impression among undergraduates appeared to be that they ought to study just enough to pass and no more; that their instructors were their natural enemies, whose business it was to find out their weak points and to condition them if possible; and that to hoodwink a professor into believing a student knew something which he did not know, was the highest possible achievement in student life.

Such a state of affairs was due to a variety of causes, among others the following being prominent:

First. The idea entertained generally by the faculty that graduation from an engineering school of high standing ought to be a case of "survival of the fittest," and that none but men of high attainments as students ought to become engineers.

Second. The admission of boys instead of young men into engineering schools.

Third. Employing as professors, to teach engineering subjects, men who were mere theorists and who had never had any actual experience in either office or field.

Fourth. The erection and maintenance of an artificial barrier between professors and students which prevented them from meeting on common, professional ground.

This spirit of conflict between professors and students is fundamentally wrong, as is also the idea that a student should study merely enough to pass the examinations. Fortunately for the engineering profession, these false notions are rapidly becoming obsolete; although I note occasionally in my travels that the same old antagonism and want of confidence still exist to a certain extent in some of the technical schools.

The notion that only ideally fine students can become good professional men is entirely erroneous. Many a slow-thinking student, who has either been dropped from his course or has just managed by great effort to pass the examinations and take his degree, has become a successful engineer; and it is well known that many of the finest mathematicians who graduate from technical schools are never heard from afterwards in the engineering world. Now do not go away with the impression that I believe it is not the good students who make the best engineers; for on the whole, they most decidedly do; but I maintain, nevertheless, that some men who as students think slowly and acquire knowledge with difficulty, after leaving the technical school, develop slowly but surely into sound, trustworthy, and high-class engineers.

I am glad to note that of late years the average age for entering engineering schools has increased by a year or two. In my class at Rensselaer, the average age for entrance was 17½, but now I understand that the average age of entrance for all the technical schools of the country is about 19 years—however, I may have been misinformed. In my opinion, the proper age for entering the freshman class is between 18 and 20; less than 18 is too young for one to appreciate fully the course, and more than 20 will shorten too much a man's working time; besides, if one starts very late on his life's real work, he is apt to have formed the habit of depending too much upon others for the necessaries of existence, so he will feel rather disinclined to earn his own living, and will be dissatisfied with the character of the said living, when compared with that to which for so many years he has been accustomed.

Again, the time is coming when a first-class course in civil engineering will demand five years instead of four.

Some 16 years ago, in a paper on "Civil Engineering Education," I advocated strongly a five years's course in civil engineering, and made an outline of what it should consist, stating that a thorough course on the subject cannot be given in less time. At present, as far as I know, there is no technical school which gives more than a four years's course in engineering; but for several years McGill University, of which institution I have the honor to be an ad eundem gradum alumnus, has been giving a year of post-graduate work; and this work is soon to be included in the regular curriculum by increasing the length of the course to five years. When this is done, Canada will lead the United States in civil engineering education, and in truth, the course in engineering given at McGill to-day is almost, if not quite, on a par with the best course given in this country.

It is an excellent plan for a boy who contemplates following the profession of civil engineering to spend a few years at college, taking an Arts course, and if time permit, the degree given with same, before entering a technical school, but in such a case he should elect to take as many of the scientific studies as possible, and omit entirely the dead languages and most of the living ones.

The study of the dead languages is a relic of the dark ages, and clings to our institutions of learning as rigidly as did the Old Man of the Sea to Sinbad the Sailor; while most of the time spent by engineering students in the study of modern languages is totally wasted. This is for two reasons: First, because not one in ten learns any more about them than merely enough to pass the examinations; and, Second, even if one should learn a modern language well, he would have no practical use for it in the United States; consequently, in my opinion, the time devoted to its study could be used to far better advantage on something of a more practical nature.

The plea that is generally made for the study of modern languages in engineering schools, is that there are so many good things in French and German scientific books of which the young engineer would be deprived, did he not study these languages. To this plea I beg to reply as follows:

First. There is very little in either language that would be of any practical value to American engineers.

Second. That, if occasionally a useful article or treatise does appear in French or German technical literature, it is very soon translated into English.

Third. There are already more good engineering books in the English language than one can find time to read; and,

Fourth. And, finally, not one student in fifty at an en-

*Extracts from an address by J. A. L. Waddell, M. Am. Soc. C. E., delivered before the students of Missouri State University, April 2, 1903.

gineering school learns a modern language with sufficient thoroughness to translate or even properly to comprehend a technical paper written therein.

The only foreign language which would be of any practical value to an American engineer is Spanish—and the technical schools do not teach that.

Instead of worrying the students's brains with Latin, Greek, French and German, why not give them thorough instruction in English, so that they would all become truly masters of their own language? What percentage of the graduates from engineering schools are well posted in English? How many of them can spell correctly? How many of them can write a decent letter? Alas! the percentage is indeed small. Of this I constantly have ample proof in the applications for work which we receive from recent graduates.

Again, I do not believe that the English language is taught properly to engineering students. Too much attention is given to the study of works of the old writers and their antiquated diction, while no time is spent in teaching the young man how to express himself clearly, tersely and emphatically. Moreover, why spend a lot of time studying and analyzing poetical works? It is plain, every-day prose, not poetry, that the engineer has to deal with in his life's work; and believe me, there is nothing which will be of greater advantage to a good engineer than a thorough, practical knowledge of his own tongue.

In giving the various courses in English (and I believe they should be distributed throughout the entire four or even five years), why not adopt, for some of the examples of standard literature, works of American engineers which are written in good English. It is engineering reports, specifications, papers and books which the engineering student is likely to write after graduating, and not novels, nor poetry, nor books of travel.

How few engineers can prepare a truly first-class specification! The writing of specifications is an art, and therefore ought to be cultivated; but unfortunately, all the engineers of my acquaintance, who indulge in the preparation of such literature, have had to learn the said art after graduation, and by means of many hard experiences. Experience is certainly a good teacher, but it is a costly one; and there is no reason why a young man leaving a technical school should not be thoroughly grounded, not only in the elements of specification-writing, but also on the finer points thereof.

Students of mathematics have a false notion that it is necessary for them to learn merely the theory, and that it is useless for them to spend time in making practical applications thereof. They think, too, that approximately correct results are good enough; or even if their figuring proves to be incorrect, it is needless to go through it again, because familiarity with figures will come later with practice. This is all wrong and most reprehensible, because it is at school that the young man should learn habits of accuracy and neatness. Without such habits he will never be truly successful, nor able to accomplish great things in his profession.

Let me urge you to be thorough in all your mathematical studies; never quit a difficult point until you have comprehended it totally and absolutely. Don't be content with thinking that you understand it, but stick at it till you know that you do beyond the peradventure of a doubt. The test of your knowledge is your ability to demonstrate the point to another student in such a clear way that he cannot help comprehending it also. This has been a guiding principle of mine for over 30 years, and I assure you, it is a good one.

I recall an extreme case of its application, which may interest you. When acting as assistant professor of rational and technical mechanics at the Rensselaer Polytechnic Institute in 1879, I was saddled with the drafting part of the various courses in descriptive geometry, but had nothing whatsoever to do with the teaching of the theory. One evening about 7 o'clock there came into my room a young sophomore, a Cuban, and by far the brightest man in his class, with whom I was on very friendly terms; in fact, he was then giving me instruction in Spanish. He told me that there were three lines in Warren's Descriptive Geometry in the problem of the cow's horn, which he could not understand, and that he would like my assistance thereon; so, of course, I had to tackle the job.

Now Windy Warren, as we used to dub him, was the blindest writer ever known to the men of R. P. I., and although as a student, I had studied his books, this particular problem had been omitted from my course. Never before in all my reading had I struck such a miserably blind, knotty case. After I had spent half an hour on the thing without producing the slightest result on my mental conception, my young friend saw that he had let me in for some hard work, which would be additional to that on which I was employed when he entered my room, and which had to be prepared for the morrow's classes in mechanics; so he expressed his regret at having troubled me and proposed to take his departure.

Knowing that if I let him go with the point unsolved, I would lose my prestige with him as an instructor, I said: "You have brought me this problem, and I am not going to quit working on it until I have solved it; and what is more, you are going to stay in this room until I have discovered the solution, so make yourself comfortable and go on with your study of to-morrow's lessons." He did so, and I continued for hour after hour to pore over those three wretched lines, till just before midnight I solved the problem and demonstrated it to the young man. The next day he was the only member of the class who was able to explain it on the blackboard.

Apropos of descriptive geometry, let me advise you to study thoroughly and well all the courses in this branch of learning, from the elementary plane problems, up through projection drawing, descriptive geometry, shades and shadows, perspective and stereotomy. It is a beautiful course of study and one of absorbing interest, involving many delightful hours of most satisfactory investigations.

If I were again a student, I would investigate these descriptive geometry branches much more deeply than is done in the ordinary engineering course, for not only would I make many extra drawings to illustrate the problems, but I would also build illustrative models with paper, wood and threads.

Once in a while in our office practice, when engaged on some unusually difficult and complicated piece of designing, we resort to modeling as an aid to a proper conception of the proposed construction. The last time we did anything in this line was in connection with the designing of the spread-span of the large bridge which we are now building over the Fraser River, at New Westminster, for the Government of British Columbia. The preparation of this model was entrusted to a young Japanese engineer, Mr. Fujino, who was first a student in our office and afterwards one of our most trustworthy assistants. The model that he manufactured out of cardboard was used by a number of our draftsmen in preparing the working drawings.

Learn how to make good perspective drawings. It is an accomplishment which may some day prove useful, especially when dealing with financial men, who often desire to see what a proposed structure will look like, and who cannot understand projection drawings.

Some young men have an idea that it is a bad thing to be a good draftsman, because one who is expert in this line is apt to be kept at drafting work, so that it does not pay to excel in the merely mechanical part of drafting. Anyone who has acted on this principle would have a very poor chance of obtaining employment in the office of my firm, for we have no use for any engineer who is incapable of making a drawing which will not do discredit to the office. There is no more reason in such an idea as this than there would be in a young merchant cultivating an illegible hand for fear that his employers may confine his services to bookkeeping. By all means learn to do lettering quickly and neatly. Proficiency in such work will certainly stand one in good stead sooner or later.

If I were in your place, I would spend almost the entire time of every vacation in doing some actual engineering work, mostly in the field on account of both the health and experience that are to be thus gained, but also partially in the office. Do not try to earn money on such work, but offer your services gratis, because, as a rule, they are worth very little in the field and less than nothing in the office. If you receive pay, you will probably be kept pretty steadily at one class of work; but if not, you will feel at liberty to ask for a varied experience. Moreover, if, when you leave, your employer thinks that you have been of actual service to him and that your work has been of real value, he is likely to present you with some small amount of money as compensation.

Remember that in England young men who are studying engineering have to pay large sums for the privilege of working for several years without salary in the employ of prominent engineers. In this country we have not come to that yet, although my partner, Mr. Hedrick, once threatened to establish in our office the custom of demanding initiation fees; for he complained bitterly of being tired of running a kindergarten and having the young men leave as soon as they had learned to make themselves useful and had become able to really earn small salaries in the employ of bridge manufacturing companies.

When spending a vacation on field work, learn as much as you can of the minor details of same, and consider nothing as infra dig. You should be able to shovel concrete, cut threads on pipes, couple up piping, saw timber, fire and oil an engine, sharpen tools, drive rivets, measure up work of all kinds, and, in short, make yourself generally useful whether you are working in the employ of the contractor or on the engineer corps. No source of information is so lowly as to be despised; because a skilled workman or even an intelligent navvy can tell you many useful things which you will not find written in any book.

There is one feature, common to the curricula of all the engineering schools in America, which I feel compelled to criticise severely; and that is the failure of the faculty to include in the course of study any reference to the history of civil engineering and its development. In consequence, the graduates are unacquainted with the great engineering works of the past, and do not even know the names of the famous engineers who are dead nor of those who are making engineering history to-day. Let me give you an illustration of this. A couple of years ago, when traveling, I became acquainted with a pleasant young fellow, and ascertained that he was a graduate of one of the leading Eastern technical schools, so our conversation naturally drifted to engineering subjects. Incidentally, I mentioned the name of my friend, Mr. Elmer L. Corthell, as being connected with some large undertaking, but the young man had never heard of him, so asked who he is. I explained that he is one of America's most eminent engineers, and that he makes a specialty of harbor work. I also said that in his younger days he had been the right-hand man of Captain Eads on the Mississippi jetties, but, mirabile dictu, the young man had not heard of either Captain Eads, or the Mississippi jetty-work. Such ignorance as this is inexcusable, but the young man was not to blame—the fault lay with his instructors.

In order to try to correct this sad state of affairs, I am going to suggest to the Society for the Promotion of Engineering Education that a number of its members combine to write a book, entitled "The History of Civil Engineering," apportioning the task among a number of them by dividing up the subject into the various specialties, letting each writer work up independently the history of that specialty, and combining all the resulting papers into a single large volume. In this way the work of many able men of both the past and the p resent would receive merited recognition, the engineering profession would obtain some most interesting and enjoyable reading matter, and the young fellows turned out of technical schools to become members of the greatest of all the learned professions would no longer be densely ignorant of that profession's history and of the names of its great men.

I am constantly advising young engineers to join the various engineering societies, and to become personally acquainted with engineers of established reputation, so I can do no better than to repeat this advice for your benefit. I counsel you also to read two or three of the principle engineering papers and magazines, so as to keep in touch with what is going on in the engineering world. After a while you should write occasionally for these periodicals.

Some inexperienced young men think that an engineer should devote his entire time to strictly engineering work, and that any portion of it spent in any other occupation is wasted. This is another fallacy that ought to be exploded. It is true that there are some engineers whose entire time is confined to purely engineering work, but these men are computers and the like, who grind away from ane year's end to another on intricate but tiresome calculations, and whose salaries never attain to munificence; while most of those engineers who spend a large portion or perhaps all of their time on business matters, earn eventually large compensation.

Learn to distinguish between the use and abuse of approximations. Some calculations should be made with extreme accuracy, while others need be only approximate. Engineers are apt to err in either direction. For instance, it is a difficult matter to teach an experienced railroad engineer that, when making a large triangulation for a proposed bridge, it is necessary to measure his base lines to a hundredth of an inch, and his angles to a second; and on the other hand, many bridge computers have wasted months—aye, years—of their lives in struggling with that useless method of figuring stresses by wheel concentrations. Your maturing judgment will soon tell you how close to exactness any set of calculations ought to be made in order to obtain correct results. Any greater accuracy amounts to mere hair-splitting.

This last phrase reminds me of an amusing incident in my career. I was once called upon to pass on some plans for a bridge which were submitted to a city by the successful bidder. Among other faults, I pointed out that the hip and pedestal pins were located on the center line of the channels of the inclined end posts instead of on the gravity line of the sections of the member. The foreign engineer who had prepared the plans wrote me in defense of the same, and stated in reply to this particular criticism that my objection was nothing but the "splitting of a hair." I thereupon sent him a copy of my calculations, showing that the little eccentricity, which he wanted to ignore, increased the maximum stress on the extreme fiber 59%. This letter brought the correspondence abruptly to a close.

There is one important matter which is neglected in most enginering schools, viz.: the use and adjustment of all instruments employed on engineering work. Of course, the use and adjustment of transit and level are taught more or less thoroughly at all technical institutions; but how many of their recent graduates can take one of these instruments apart, clean it, effect simple repairs, and put it together again? All these manipulations are necessary occasionally on field work, where the party is hundreds, perhaps thousands, of miles from the nearest repair shop.

Again, there are nowadays in use by engineers several improved attachments to the transit and level; and these two are by no means the only instruments which engineers employ.

Take my advice and learn all you can concerning engineering instruments before you leave your alma mater; for you may not have another opportunity to do so before you are required to apply the knowledge that I am advising you to acquire. Moreover, you are liable to forget in time a great deal of what you learn here about instruments. In proof of this let me give you a little illustration from my own experience:

Last summer the Chief Engineer of the Province of British Columbia (who, by the way, is a very old friend of mine) and I found ourselves some 500 miles up the Fraser River, about the 52 parallel, provided with a borrowed transit and level but no one to run them, and having before us the task of locating a suspension bridge across the river and the approaches thereto on both sides of same. There was nothing for us to do but to get down to first principles and operate the instruments ourselves; but as they had traveled some 200 miles by train and nearly as much more by stage, it was first necessary to see that they were in adjustment.

"How long is it since you ran an instrument?" asked my friend.

To which I replied, "Over twenty years."

"Well, " said he, "I have not touched one for twenty-five. Do you know anything about making the adjustments?"

"Yes, at least I ought to," I answered, "for I gave the course in adjustment of instruments at Troy, but probably I have forgotten all about it."

We first tackled the transit and found that we could remember the three adjustments pretty well, so tested for them and soon got that instrument into good shape. Next we tackled the level, which we found to be a dumpy.

We set it up and looked at it a few minutes without speaking. At length my friend remarked:

"Confound a dumpy level, anyway; I never could handle decently one of the infernal things. How in Hades are we going to get it adjusted?" I replied: "If I remember rightly, we shall have to use the peg method, but it is over 25 years since I handled one of the accursed instruments, so I have forgotten nearly all I ever knew about the adjustment."

To make a long story short, we two old engineers struggled with that miserable instrument for three-quarters of an hour before we got it into sufficiently good adjustment to answer our purpose, after which we proceeded with the surveys, finding by degrees our old skill coming back to us to such an extent that, on the third day, when we had finished our work, we agreed that we had enjoyed it thoroughly, notwithstanding the fact that we had slept for two nights in the rain without any shelter but our blankets and a small piece of canvas.

The maintenance of a high standard for the engineering profession is the duty of every engineer both to the profession and to himself. The strictest integrity under all circumstances is absolutely essential to an engineer's success. Any departure therefrom is sure to bring disaster to the individual and disgrace to the profession, so let me exhort each of you to do always the right thing to the best of your knowledge and power.

At all times you should endeavor to maintain the dignity of your profession, remembering that the public is not likely to place that profession upon a higher plane in the affairs of men than do its own members; so never speak of it in a belittling tone; but, like a knight of old in respect to his lady's fame, be ever ready to maintain its superiority against all comers.

In order to encourage you young men to renewed effort, let me state that I most firmly believe civil engineering to be less overcrowded than any other profession; that the demand for good engineers is increasing steadily; that the problems confronting engineers are yearly becoming more complicated, demanding a higher grade of talent and training; that the remuneration for engineers of all ranks in this country is higher than ever before; and that the prospects for the future of our profession are exceedingly bright.

AN AUTOMATIC MINE CAR TIPPLE.

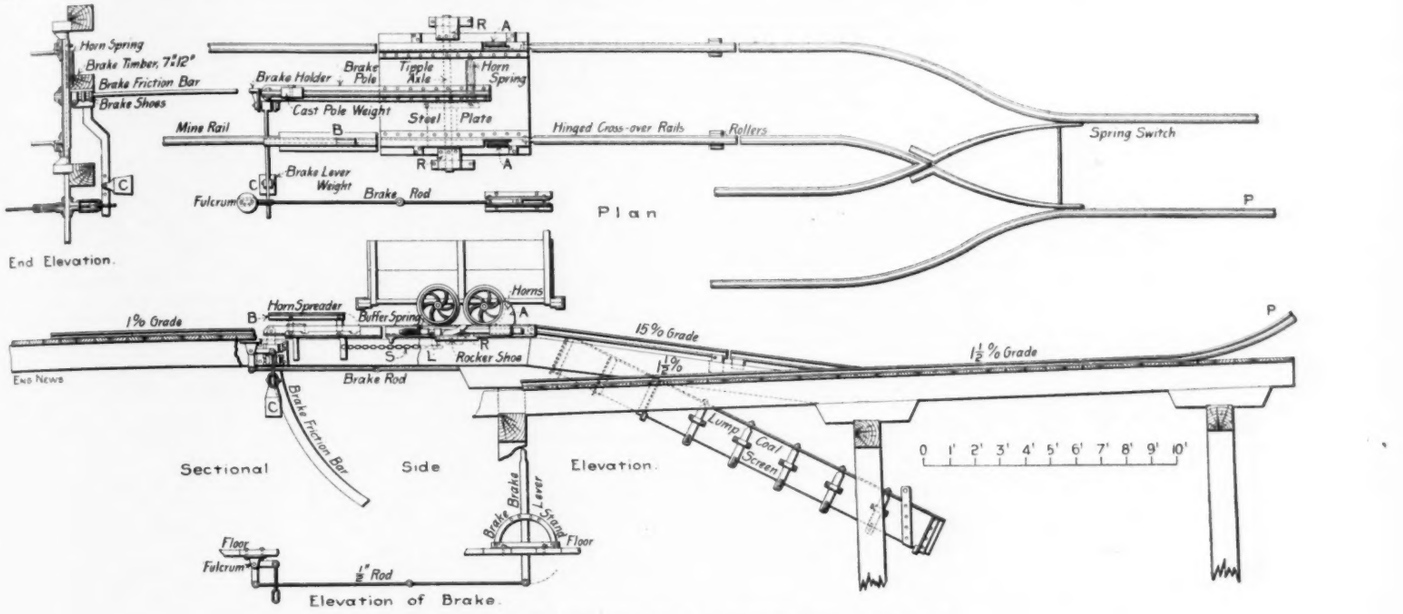
We illustrate herewith an automatic car tipple of decided merit. It has been in use for some time at a number of large mines, including some of those of the Cambria Steel Co., the H. C. Frick Coke Co., and the Anaconda Copper Mining Co. The feature of greatest merit is the fact that hand labor is entirely dispensed with in moving the cars up to and away from the tipple, all this work being done by gravity.

The loaded car of ore or coal comes down the 1% grade (Fig. 2) and stops on the tipple when its front wheels strike the horns A. The man operating the brake lever permits the tipple to tip forward on its rockers, R, until the ore slides out the open front end of the car. After thus discharging the load, the tipple rights itself automatically, the now empty car being still held by the horns A. When the next loaded car arrives its front wheel strikes the horn-spreader, B, and pushes it forward and downward, thus pulling the chain S, which rotates the horn-shafts, L, to which the horns are keyed. This rotating of the horn-shafts moves the horns outward, releasing the wheels of the empty car.

The empty car then coasts down the 15% grade and up the short raised track to a point, P, where it comes to rest for an instant before coasting back down to the automatic spring switch, and so down the track for empty cars. In the meantime the loaded car has been caught by the "horns," and dumped by the operator.

It should be noted that the horn-shafts, L, on which the "horns" rotate have a slight longitudinal play and are provided with heavy buffer springs to take up the jar caused when the loaded car strikes the horns. A "horn spring" pulls the horns to an upright position as soon as the rear wheels of the loaded car passes off the horn-spreader, B. Thus it is impossible for a loaded car to get past the tipple, or to dump itself, for the brake is always locked when the tipple is in its normal position.

This dump or tipple weighs 3,500 to 6,000 lbs., depending upon the size of the car to be handled. It is manufactured by the Phillips Mine and Mill Supply Co., of Pittsburg, Pa., to whom we are indebted for blue-prints and photographs from which our cuts have been made.



FIGS. 1 AND 2. PLAN AND ELEVATION OF AUTOMATIC CAR TIPPLE.
Phillips Mine Supply Co., Pittsburg, Pa., Manufacturers.

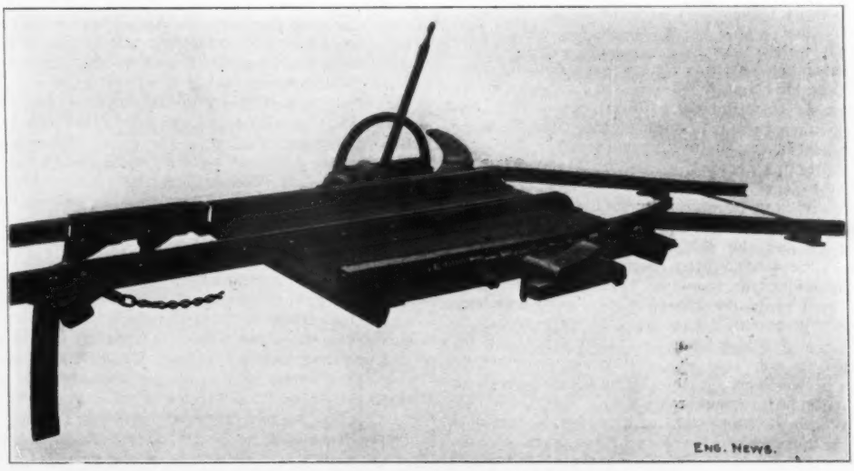


FIG. 3. PERSPECTIVE VIEW OF CAR TIPPLE.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The thirty odd letters from prominent members of the American Society of Civil Engineers relative to the policy of that society toward the proposed Union Engineering Society House, published in this and our preceding issues, form a most instructive indication of the sentiment of the membership.

Inasmuch as these letters were sent for publication in response to our request, we have of course refrained from editorial comment or criticism upon them, although many of the ideas presented furnish an inviting subject for discussion. At present we merely wish to make an urgent plea to the members of the society to consider the new plan purely on its merits, without prejudice, and with regard to the future welfare of the society and the profession rather than to ideas and precedents of the past.

In asking the members to consider the matter without prejudice, we have particularly in mind the report which has come to us from several sources, and has found published expression in a contemporary that the society has been led into the proposed coöperative action by persons entirely outside its membership.

We believe the origin of this idea is due to the fact that most of the members have obtained their information concerning the project from the inaccurate reports in the daily papers. This is so manifestly unfair to the project as well as to the members of the various societies who have been carrying on the work purely with a view to the benefit of the profession as a whole, that the members ought to free their minds absolutely of any prejudice based on such grounds.

Instead of the American Society of Civil Engineers being led into the project by outsiders, the fact is that it has taken a prominent part in it from the start.

Mr. Carnegie made known his beneficent plan at the outset, it is true, to two officers of the Institute of Electrical Engineers, with one of whom, we believe, he was personally acquainted. These two gentlemen, immediately on leaving Mr. Carnegie's house, went to one of the most prominent members of the American Society of Civil Engineers, who has served the society both as a Director and as Treasurer, and consulted with him as to the action which should be taken. On the following day Mr. Carnegie's offer was made known to a conference at which all the societies concerned were represented by officers, and the American Society of Civil Engineers was represented by its President, its Secretary, the former treasurer and director above referred to, and one of its most widely known honorary members. In other words, out of the eleven gentlemen present at this conference four were officers or members of the American Society of Civil Engineers and as well entitled to represent it as any that could have been selected.

It will be obvious to every one that to make the project known to general membership of the societies or even to their several governing bodies before the options on the necessary real estate were acquired would have been practically impossible, if the purchase of the site desired was to be arranged at a reasonable figure. Even as it was, the news of the project escaped and was made public by the daily press before the time set by the committee. Doubtless some of the members of the governing bodies of the various societies felt some resentment when they learned that so important a project had been under consideration without their knowledge. The above statement should make it clear, however, that such a feeling—natural though it may be—is ill-founded. If the news of the project had not been prematurely published in the daily press, the committee would doubtless have furnished a statement of the project to the governing bodies of each of the societies before making it publicly known.

Some prejudice against the new project may be based on the ground that the societies do not need or should not accept outside aid. To those who may be influenced by such considerations we would suggest that Mr. Carnegie is not by any means an "outsider." On the contrary, he is and has been for thirteen years a Member of the American Society of Mechanical Engineers in good and regular standing. He has been for fifteen years a Member of the American Institute of Mining Engineers. Of the Iron and Steel Institute, without doubt the greatest society in the world devoted to metallurgical engineering, Mr. Carnegie has been a Member since 1879, has served the society as a Vice-President and is now its President. Whether we accept these evidences or take Telfod's classical definition of Engineering, we judge Mr. Carnegie's title to be considered a member of the engineering profession to be as good as that of the great bulk of the membership in any of the societies. Very likely he could not pass a civil service examination for a subordinate position; but neither could ninety-nine per cent. of the other distinguished members of these societies who have reached a like mature age.

Mr. Carnegie's great offer, therefore, is not from an outsider, but from a fellow-member of the engineering profession to his brothers in the professional organizations. It is for the advancement and upbuilding of the profession and its prestige—the exact object which all the societies hold as their chief aim.

The discussion upon the merits and demerits of the metric system and upon the proposed legislation to compel its use in government work has assumed voluminous proportions. Our readers will recall the paper of Mr. Halsey, read at the December meeting of the American Society of Mechanical Engineers and printed in abstract in our issue of Dec. 11. The Society has now published Mr. Halsey's paper in full with the discussion upon it, and it makes a book of 231 pages. The Society is distributing these to its members and at the same time is sending them the report of a "bi-partisan" committee, coving 83 pages, on the points brought out in Mr. Halsey's paper and elsewhere respecting the adoption of the metric system. With these papers are distributed ballots on which the members of the Society are invited to express their preferences.

The bipartisan committee was made up of Messrs. Jas. Christie of the American Bridge Co., and Fred. J. Miller of the "American Machinist" representing the pro-metric side, and Messrs. Geo. M. Bond of the Pratt & Whitney Co., and Wm. Kent of Engineering News, representing the anti-metric side. Any of our readers whose appetite for metric or anti-metric arguments has not been satisfied with the letters published in Engineering News during the past few months, should apply to the Secretary of the American Society of Mechanical Engineers, 12 West 31st St., New York city, and obtain copies of the above-mentioned pamphlets.

In commenting in our issue of April 30, on the financial results stated in the annual report of the General Electric Co, we find we were led into some errors and inaccuracies through the fact that the complete report was not at the time before us. Comparing the gross sales of the current year and the reported profit of $10,232,838 it appeared that of the average selling price of the company's product nearly 28% was profit. The full report, however, shows that the gross profit above reported was not all due to sales. It was contributed to from the following sources:

Royalties and sundry profits	$814,959
Dividends and interest on stocks & bonds owned	293,961
Interest and discount	253,882
Profit on stocks and bonds sold at prices above their book value	973,650
Total	$2,436,452

Deducting this amount from the gross profits, we have left a profit of about $7,800,000, in round numbers, on gross sales of about $36,700,000.

We also noted in our issue of April 30 that the company carries its factory plants on its books in presenting its balance sheet at a valuation of only $5,000,000, while its total assets are shown to be nearly $50,000,000; and we queried whether the valuation of the factory plants had not been largely written down. The full report shows this to have been the case. On Jan. 1, 1903, the book value of the company's factory plants was $3,958,528.

From that date to Jan. 1, 1903, additions to lands, buildings, machinery, etc., have been made (over and above all ordinary expenses for maintenance and repair) amounting to $10,767,677.

The total book cost of the plant is $14,726,205. There has been written off during the last ten years a total of $9,726,205, leaving the book value of the plants Jan. 1, 1903, $5,000,000.

There can be no doubt that the book valuation is far below the actual value of the factories, measured either by their cost, their output, or the profits earned by them. It is, of course, generally considered conservative bookkeeping to write down the valuation of property whose value depends on the continued prosperous conduct of the business. In view of the fact that during last year the company spent nearly $3,000,000 upon additions and improvements to its manufacturing plants it would be fully justified in carrying its factory plants on its books as representing at least $10,000,000 of value.

The management of police organizations is not commonly considered engineering work; but there is no doubt that the ability to organize, systematize, and control large undertakings which the high class engineer must possess should make him well fitted for such work. It is, therefore, of interest to note that the present Police Commissioner of New York city, Gen. F. V. Greene, is a Member of the American Society of Civil Engineers, and the Deputy Commissioner, Capt. Alex. R. Piper, is an Associate of the same Society.

The practice of offering prizes for competitive designs, for public and even for private works, is widespread in continental Europe. It is most common in architectural work, where the practice has been extended gradually from the largest special problems down to comparatively small

work involving nothing more than questions of personal taste, such as the construction of a church or a municipal building in a small city. In engineering work prize competitions for designs preliminary to final plans are less common but are yet of sufficiently frequent occurrence to make them an important feature of professional practice.

For example, most if not all of the large bridges built in Germany, Austria or Italy during recent years resulted from such competitions. In these the various bridge-building companies usually took a leading part, and it is worth noting that where such a company received first prize it was generally also given the contract to execute the work; in fact, the rules under which many competitions of this kind are held give the winner a preferential interest in the award of the contract for execution. We are told by one who is familiar with the state of affairs in Austria and Germany that a bridge company which enters a design competition for the construction of an important bridge often spends as much as $10,000 in the preparation and working out of its design to be submitted in the competition. An even more significant development is that the leading national societies of the different countries have drawn up standard codes of rules to govern design competitions, and that these societies have on several occasions inaugurated prize competitions among their members purely as an academic study.

In America there is little favorable feeling among engineers for this method of securing designs, and with a few notable exceptions no prize competitions for engineering works have been held in this country. The same statement holds true concerning architects, even though the argument for the competition idea is much stronger in their case for the reason that individuality and artistic inspiration enter so largely into their work. The consulting engineer or architect in this country feels that there is something unbusinesslike, not to say unprofessional, in the plan of submitting a carefully studied and elaborated design to the lottery of a prize competition the judges in which are at best his professional colleagues and at other times, perhaps, his competitors. The vast amount of labor represented by the scores of designs entered in some of the large competitions calls his attention to the small chance which each single competitor has of drawing a prize. He cannot but feel that in the long run a large part of his labor is wasted if he engages in such competitions. The manufacturing or building companies, on the other hand, exist for the purpose of constructing work, relying for their contracts on their ability to do the work most cheaply and effectively. It is outside their province to complicate the conditions under which they secure their business by engaging in work which belongs strictly to the designing and consulting engineer. (It must be said, however, that the recent growth of extensive corporations of designing engineers, affiliated usually with certain manufacturing interests, somewhat modifies this statement.)

We are led to make these remarks by the announcement of a large design competition probably the largest ever held in point of prizes offered, which we note in another column of this issue. The Austrian government desires a solution of the problem of planning canal lift works at a point where an elevation of over 100 ft. is to be surmounted by the canal connecting the Danube and Oder rivers, and for this purpose offers three prizes, aggregating $45,000, for the best designs. The competition is open to engineers of all countries and nationalities—which is not usually the case in these European competitions—and the expressed intention is to have the best engineers in this field from all over the world contribute their ideas. The magnitude of the prizes offered is well adapted to secure this end. It is quite probable that there will be some Americans among those competing; in any case the final result will be a matter of general interest. Differences in level as great as that proposed are most unusual in canals or canalized rivers, that is to say, they are rarely concentrated at one point. The lift is greater than the elevation of the summit level in the Panama canal (for which no lifting device other than locks has ever been seriously considered), but considerably smaller than the difference in level to be overcome in the proposed Niagara ship canal. However the Austrian problem specifies only small vessels, while at Panama, for instance, the largest ships in the world must be accommodated. The size of vessels to be handled is, of course, a very serious factor in determining the applicability of any particular plan, so that the careful selection of a design for a given special case is not necessarily of much value for cases involving other conditions.

THE UNITY OF THE FOUR GREAT BRANCHES OF THE ENGINEERING PROFESSION.

Within recent years much has been said of the importance of specialization in engineering. There is perhaps a tendency to forget that to attain greatest success as a specialist the engineer must possess a fair knowledge of every branch of engineering.

Historically, we know that the first railway was invented by practical miners, and was developed by self-educated mining engineers. On the other hand two of the most valuable machines used by the mining engineer were invented for, and developed in, civil engineering work. We refer to the rock drill and to the stone crusher. The percussion power drill was developed into a practical everyday machine in the work of driving the Hoosac tunnel. The first successful stone crusher was used in crushing rock for macadam roads, and its inventor probably never dreamed of its present enormous use in breaking ore for milling purposes. To the engineer who is ever on the alert to economize in production, the foregoing two examples serve to illustrate the importance of watching the progress of engineering science in other branches than his own specialty.

The derivation of the word engineer and its French equivalent, *ingenieur*, imply the exercise of ingenuity. An engineer of the highest type is always an inventor. He seeks to learn all that other engineers have done in the way of economic production, and then combines the knowledge so acquired with that derived from his own experience or reasoning.

The engineer applies science to economic production; and his genius is measurable therefore in dollars and cents. To quote again Mr. McHenry's definition, to which we have frequently referred: "Engineering is the art of making a dollar earn the most interest." Herein the engineer differs from all other professional men, but in this essential characteristic engineers of all classes are alike.

No sharp lines can be drawn between civil, mining, mechanical and electrical engineering works. Thus a consulting mining engineer must not only be familiar with the chemical, mineralogical and metallurgical parts of his professional stock in trade—the parts that really differentiate mining from civil engineering—but he should be familiar also with numerous other fields. For example, he should have a knowledge of electrical engineering; and not a mere smattering, but a clear understanding of the principles of electrical engineering work. Water power is frequently available in the mountain districts where ores are usually mined, and the mining engineer should know enough of the generation, transmission and utilization of electricity to be able to advise his clients as to the economic applicability of electric power in any given case. It may be said that the mining engineer should take the advice of an electrical engineer; but if he does this he will fail to fulfil the reasonable expectation of his client. It is the mining engineer that should in all ordinary cases take the responsibility of deciding whether or not to use electric power. After he has decided to use it is the time to call in the electrical engineer to plan the details.

On the other hand, the consulting electrical engineer should have a knowledge of mining methods and conditions, for economic design is impossible without such knowledge. Thus the electrical engineer may be called upon to design and install an electric mine plant which is to be used for hoisting, ventilating and drilling. If he is not familiar with mining conditions, he is practically sure to make costly blunders. Take the electric drill, for example. He may have seen one of a certain type used in a quarry, or in an experimental shop, with most excellent results. He therefore recommends it. Later he learns that the highly corrosive acid waters, dripping from the roof of the mine, quickly eat away and destroy certain parts of the drill mechanism; or he finds that the rough handling of the drill by the miners, as they hurriedly remove it before blasting, rapidly knock the drill into a condition of "innocuous desuetude."

It may be replied to this line of reasoning that the mining engineer should have forewarned his electrical professional brother by stating the conditions. However desirable it may be that the two engineers work thus together, in practice they seldom do; and the mining engineer may never for a moment suspect that the electrical engineer does not know that iron pyrites by oxidation produces sulphuric acid which is highly corrosive; or he may fail to consider that a man must actually have seen or read of conditions in order to have them in mind when busy with a design.

Whether it be in spanning a continent with rails of steel, or in mining the ores from which that steel was made—whether it be in designing locomotives to haul cars over those rails, or in making a dynamo to light these cars, men of the four great divisions of engineering science are working together and with one object—economic production.

In view of all these facts, is it not the veriest absurdity for one division of engineering work to claim superiority to another? All alike are founded on the great fundamental laws of physics and chemistry. Each at the present day has equal claim to be considered a scientific profession and not an empirical art. No great work of the first rank can be carried out without the aid of all four divisions of the profession and their hearty coöperation with each other.

And if this coöperation can exist in the work of the profession for the public, why should it not also exist in the work which the profession does for its own improvement and advancement? Specialization in this work has been found beneficial; and new organizations are all the time coming forward devoted to particular specialties in professional work. As illustrations of such specialization we may cite the Society for the Promotion of Engineering Education, the Engine Builders' Association, the Society for Testing Materials, the Railway Engineering Association, the Municipal Electricians' Society. Such specialization is advantageous to the profession, but it is perfectly compatible with harmonious coöperation for the attainment of common ends.

We have long maintained that the profession as a whole is heartily in favor of coöperation. The response of the great engineering societies to Mr. Carnegie's munificent offer seems to us to fully prove this. Such letters as those which we have printed from members of the American Society of Civil Engineers in this and our preceding issues are conclusive evidence that the leaders of the engineering profession are glad to emphasize the profession's essential unity and to work for harmonious coöperation among the organizations representing its various branches.

LETTERS TO THE EDITOR.

The Manufacture of Hollow Pressed Steel Car Axles by the Hungarian Government Iron Works.

Sir: In reference to the article "The Manufacture and Properties of Hollow Pressed Steel Car Axles," in your issue of May 7, I take the liberty of informing you that the described method is no more a new one. Nearly the same method is employed in the steel works of the Hungarian Government in Diosgyör.

The method was adapted from the procedure used in the manufacturing of gun-shots, in which branch the above-named steel works occupies a prominent position and possess the great majority of delivery for the Austro-Hungarian army. In manufacturing hollow steel car axles the Hungarian steel works have also obtained excellent results in every respect and now intend to introduce them to all government railways. Yours truly,

Zoltán Oberschall.
Ex-Assistant Chief Engineer of the Steel and Iron Works of the Hungarian Government.
124 E. 26th St., New York, May 15, 1903.

Diagram for Concrete-Steel Beams.

Sir: Will you kindly tell me whether the diagram for obtaining percentage of steel and moment of resistance of concrete-steel beams as published in April 30 Engineering News is correct? I notice the values of $\frac{M}{b\,h^2}$, starting with zero continue in the progression 40, 80, 120, etc., to 280 inclusive. The number following 280 is 300. Should it not be 320? Yours truly,

J. L. Parke.

1724 Brook St., Louisville, Ky., May 12, 1903.

(The error referred to is in the abscissa scale of the diagram accompanying the letter of Mr. J. W. Schaub in our issue of April 30. The figure 300 should evidently read 320, the preceding and following figures being 280 and 360.—Ed.)

Closing Mississippi Crevasses.

Sir: In your issue of May 7 is reproduced the interesting description by Mr. Wilkinson of his very able closure of Magnolia Crevasse, in the Louisiana Levee.

In 1897 the Flour Lake Crevasse, in the Yazoo-Mississippi Delta Levee District was closed by substantially the same process as that used in the building of Mr. Wilkinson's second dyke, with these differences in the local conditions:

First, the gap in Flour Lake Levee was 2,050 ft. long. Second, the water was flowing through, along the entire route of the dyke, at a depth of 2½ to 6 ft., with one wide channel 11 ft. deep, there being no temporary dyke in front to restrain the flow during construction. Third, there was no railroad to haul materials on, and sacks of dirt had to be wheeled on barrows an extreme distance of 1,400 ft. Very truly,

A. L. Dabney, M. Am. Soc. C. E.

43½ Madison St., Memphis, Tenn., May 9, 1903.

Capacities of Plate Girders.

Sir: I have noted the suggestion of Mr. C. T. Morris in your issue of the 7th inst. regarding the introduction of a column giving section moduli into the tables of Capacities of Plate Girders published in your issue of April 16. Having also received a similar suggestion in a personal letter from a Pittsburg friend, I wish to show a short cut that will help Mr. Morris and the other gentleman over a portion of their difficulties.

I think there is no question that the bending moment capacity (or moment of resistance) varies directly as the unit working stress. Then assuming the following algebraic notation:

P = any unit stress,
R = corresponding moment of resistance,
R^1 = moment of resistance given in table under heading "Bending Moment, Ft.-Lbs.,"

and remembering that the unit stress for which the tables were computed is 10,000 lbs. per sq. in., we have

$$R = \frac{P\,R^1}{10{,}000}$$

In other words, by moving the decimal point four places to the left in the tabulated value of R^1, we have the section modulus, and by multiplying it by the new unit stress the new moment of resistance is obtained.

As long as the question as to the advisability of using one-sixth of the net area as available for taking bending stresses is in dispute, Mr. Morris' suggestion of an additional column including the value of the web for resistance bending is certainly a good one. Your truly,

F. L. Batchelder.

Houghton, Mich., May 10, 1903.

Single-Leg Connections for Angles.

Sir: I have chosen as a subject for thesis "The Strength of Angles with One-Legged Riveted Connections." May I ask a few questions concerning it?

What percentage of bridges is riveted and what percentage pin connected? To what extent are one-legged connections used, and up to what sizes of angle? Will the knowledge of the strength of such connections be of use to the profession? Thanking you for your answer, I am, sincerely yours,

R. E. Kimball.

Tufts College, Mass., May 15, 1903.

(It is hard to say what percentage of American bridges is riveted. Up to recent years no large riveted bridges existed in this country, though now there is a fair number. Still, the large majority of long-span bridges are still being built pin-connected, and doubtless this will continue for a long time to come. All but a very few small bridges are riveted, and nearly all roof work is riveted.

Most engineers make no distinction in allowed stress between single-leg and two-leg connections for members consisting of a single angle; when the connection has a number of rivets corresponding to the tensile (or compressive) strength of the member they call the connection ample. On the other hand there are engineers who specify that a single angle shall be connected by both legs or the strength of the member will be considered less; usually the reduced strength is taken equal to the value of one leg at ordinary unit stress. In case of double-angle members the question of one-leg connection does not usually arise. We doubt whether single angles smaller than 3-in. leg are often given other than a single-leg connection; but sometimes the very largest angles are riveted only through one leg, though this is usually evidence of poor design.

Some tests have been made as to the strength of single-leg connections in members of different sizes and lengths, etc., which our correspondent will doubtless run across during his thesis work. But these tests are few in number and incomplete, and we believe that a good series of carefully executed tests will be welcome information to structural engineers.—Ed.)

Right and Left in Structural Work.

Sir: The notation "Right and left with respect to . . . only" is used in structural work, as for instance in the following note on a drawing:

Columns 1 and 2 are right and left with respect to connections X and Y only.

I wish to ask (1) is the notation correct? and if it is correct, please define right and left and state what modifications are caused by the above-mentioned notation.

"Draftsman."

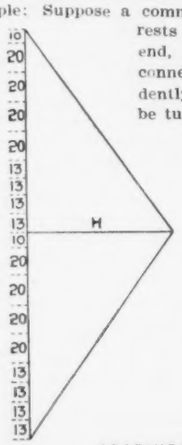
Pittsburg, Pa., May 15, 1903.

(The phrase referred to in the above should be perfectly clear without further explanation. Its meaning appears for instance from the following example: Suppose a common pitched roof truss rests on a brick wall at one end, while the other end connects to a post. Evidently such a truss cannot be turned end for end. Usually the two end trusses of the roof are identical except that the purlin clips, connections of lateral bracing, etc., are on opposite sides for the two trusses. These trusses would then be "right and left," that is to say, if the trusses be considered to be identical in elevation the near side of one as shown by the top or bottom plan becomes the far side of the other, or otherwise, if the top and bottom plan be identical for the two trusses, the elevation of the "right-hand" truss must be turned end for end to produce the "left-hand" truss. But sometimes not all of the asymmetrical features are to be changed from one side to the other in making a left-hand truss. Thus, take the case of two trusses which have their bottom lateral connections on the same side, but which form the two ends of a series of sway-brace panels. Then the two trusses are identical except that the connections for the sway-bracing are at the front side of one truss and at the rear side of the other truss. It is then perfectly proper to mark the drawing showing the (right-hand) truss with a note:

Make 1 Truss Right hand as shown.....Mark T 21
1 Truss Left hand.....Mark T 22

T 21 and T 22 are right and left with respect to details —and—(referring to the sway brace connections by appropriate letters) only.

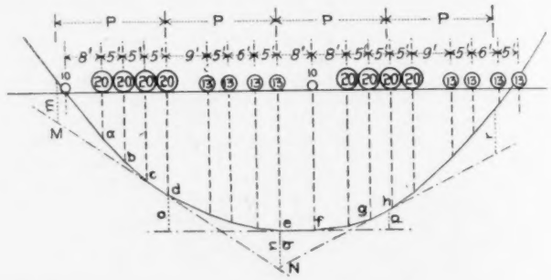
This method of noting changes on a drawing is therefore perfectly correct when properly applied. As to its meaning in any one case (our correspondent's second question) it must always be taken to cover all asymmetrical details. Two trusses which in actual position are right and left to each other may yet be identical, being simply end to end to each other. Such trusses must never be marked right and left on a drawing. It should be remarked here that many draftsmen use the "right and left" notation to an extent that constitutes an abuse of the system. It should always be remembered that while the interchange involved is readily seen when applied to the whole truss on the drawing, it is a different matter for the templet-maker, the layer-out and the assembler to promptly see how each member is affected. In many cases where the "right and left" mark is used, it would be better in the end to make a separate drawing for the "left-hand" object.—Ed.)



A Graphical Method of Finding Floorbeam Concentrations Under Wheel-Loads.

Sir: In connection with the subject of wheel-load calculations, brought by Mr. M. F. Brown in Engineering News, of March 26, it may be of interest to describe a device by the writer for finding floorbeam concentrations under a given set of wheel-loads. The method is graphical and very simple, and the writer is not aware that it has been used before.

In the accompanying figure is represented a set of wheel-loads of two engines in tandem (Cooper's E. 40 in the case shown). Their spacing is shown to scale, and at the left is drawn a load line for the wheel-loads, for which any convenient scale may be used. Now, taking any pole distance H, draw the funicular or moment polygon a b c d e f, etc. The truss for which it is desired to find the floorbeam concentration has a panel-length P, which is marked off on a slip of paper to the same scale as the wheel spacing. Suppose it is desired to find the load on a floorbeam when the fifth wheel is at that panel point. The slip of paper is shifted to bring a panel point over the fifth wheel, as shown in the figure; the vertical through the panel point gives the point d of the moment polygon. Either of the two polygon lines meeting at d, say the side c d, is prolonged to intersect the verticals through the adjacent panel points on either side, M and N being the points of intersection. The intercepts on these verticals between line M N and the polygon are m and n. If the pole distance H be equal to the panel length P, then m + n, measured by the load scale, will be the concentrated panel load at d.



GRAPHICAL DETERMINATION OF FLOOR BEAM CONCENTRATIONS.

For, the line m multiplied by the pole distance H, represents the moment of wheels 1, 2, 3 and 4, about the vertical at M, while n, multiplied by H, represents the moment of wheels 5, 6, 7, 8 and 9, about the vertical through N; and if the shears at d due to the loads in either panel be called R and R_1, then

$$Hm = P\,R \text{ and } Hn = P\,R_1$$

from which, if P = H, we find

$$R + R_1 = m + n.$$

If P be greater or less than H, multiply m + n by the quotient $\frac{H}{P}$ to get the panel load, for from the above equations

$$R + R_1 = (m + n)\,\frac{H}{P}.$$

This result is derived from a property of the funicular polygon which may be stated thus: If two polygons with pole distances P and H be drawn for the same loads, the corresponding intercepts are inversely proportional to those distances. That is, if m or n be the intercept for pole distance H, then $m \times \frac{H}{P}$ or $n \times \frac{H}{P}$ will be the intercept for pole distance P.

It is evident from this that only one polygon need be drawn and used, to get panel concentrations for various panel lengths. Only two or three trials are needed to lo-

rate the position of wheels for maximum concentration for any given panel length.

In calculating a truss with the loads so placed as to give the maximum concentration at a given panel point, the remaining panel loads are rapidly found by laying off the panel lengths to the right and, as before, producing the sides of the polygon intersected by the verticals through those panel points. Thus, the second panel point falls at c, and the sum of intercepts O and P gives the panel load at that point when P = H; for the third panel point the load is represented by q + r. These are to be multiplied by $\frac{H}{P}$ when H and P are not equal.

Scales of 1 in. = 5 ft., and 1 in. = 10,000 lbs. will give sufficiently close results.

Yours truly, R. H. Bulloch.

108 President St., Savannah, Ga., April 11, 1903.

Notes and Queries.

"W. R. R." writes:

Would some one please give the average age of old steel rails which are exposed to oxidation in such places as forming a support for the covering of stone box culverts of large span, as used by some railways.

PROCEEDINGS OF THE JOINT CONFERENCE FOR A UNION ENGINEERING BUILDING.

We have been furnished with the following official report of the meeting on May 15 of the joint conference upon the proposition of Mr. Andrew Carnegie to erect a Union Building for the National Engineering Societies:

A meeting of the representatives of the five organizations named by Mr. Carnegie, in his proposition to give to the four national engineering societies, and the Engineers' Club, a building for their joint use and occupancy, was held pursuant to call, at the Engineers' Club in New York city, on the evening of Friday, May 15.

There were present on behalf of the American Society of Civil Engineers, Messrs. Alfred Noble (President), and W. J. Wilgus and Geo. H. Pegram, Directors. On behalf of the American Institute of Electrical Engineers, Messrs. Chas. F. Scott (President), and T. C. Martin. On behalf of the American Society of Mechanical Engineers, Messrs. Jas. M. Dodge (President); Charles Wallace Hunt, Past-President, and F. R. Hutton, Secretary. On behalf of the American Institute of Mining Engineers, Messrs. A. R. Ledoux (President), Theo. Dwight, Asst. Secy., and Chas. Kirchhoff, Past-President. On behalf of the Engineers' Club, Messrs. John C. Kafer (President), W. A. Redding and W. H. Fletcher.

The meeting was called to order by President Kafer, of the Engineers' Club, and on motion Mr. Charles F. Scott, President of the Institute of Electrical Engineers, was elected Chairman of the meeting, and Mr. F. R. Hutton, Secretary.

The Chairman opened the meeting by reference to the questions which were to be considered, and called on Mr. Redding for a presentation of some of its legal aspects. After a full and harmonious discussion, the meeting passed the accompanying resolutions.

The Secretary was directed to transmit a copy of the resolutions, as passed by the meeting, to each Chairman of the Constituent committees present, with a request that the latter should transmit the action of the meeting to the governing body of each respective organization.

On motion adjourned, subject to call of the chair.

F. R. Hutton, Secretary.

RESOLUTIONS ADOPTED AT THE JOINT CONFERENCE.

1. Resolved, That this Joint Conference Committee, recommend to the respective governing bodies represented at this conference, that the following resolutions be brought before the several organizations to be acted on.

2. Resolved, That (insert name of organization) unite with (insert the names of the other four organizations) or any of them, for the purpose of accepting the sum of $1,000,000 as a gift from Mr. Andrew Carnegie, for the purpose of erecting suitable buildings for occupancy by various societies of engineers and the Engineers' Club, on the sites secured for that purpose on the north side of 39th St. and south side of 40th St., west of Fifth Ave., in the city of New York, in the state of New York.

3. And Resolved Further, That (insert name of organization) has a very high appreciation of this generous gift of Mr. Andrew Carnegie, and this additional evidence of his recognition of the engineering profession and his deep interest in the welfare of the national societies of engineers and the Engineers' Club.

4. And Resolved Further, That a site on the north side of 39th St. shall be purchased and held by trustees, or otherwise, as shall be determined by the joint committee hereinafter mentioned for the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Institute of Mining Engineers, or by such of them as shall vote in favor of coming into this enterprise.

5. And Resolved Further, That a joint committee shall be created to be composed of three members of each organization that shall unite in accepting said gift of $1,000,000 from Mr. Andrew Carnegie, and that the governing body of (insert name of organization) shall elect three members of this organization to represent it on and be members of such joint committee; and that the governing body of (insert name or organization) shall have the right and power to remove any member of such joint committee who shall be elected by it and to elect any member of this organization to fill any vacancy that shall occur in such joint committee by reason of the death, resignation, refusal to act or removal of any member who shall have been elected by the governing body of this organization as a member of such joint committee.

6. And Resolved Further, That the character and internal arrangement of the building to be erected on the site of 39th St. shall be determined upon by the affirmative vote of at least two-thirds of all of such of the members of said joint committee as shall represent all of the organizations, other than the Engineers' Club, on such joint committee; and that the character and internal arrangement of the club building to be erected on the site on 40th St., shall be determined upon by the affirmative vote of all of the three members of such joint committee who shall represent the Engineers' Club on such joint committee.

7. And Resolved Further, That said joint committee shall, by the affirmative vote of at least two-thirds of all the members thereof, select and employ an architect to prepare the plans and specifications for the club building, to be erected on the site on 39th St., and for the club building to be erected on the site of 40th St.; and shall also obtain proposals for the erection of both of such buildings; and shall have power to make and enter into such contract or contracts as shall be approved and authorized by the affirmative vote of at least two-thirds of all the members of said joint committee, for the erection of both of such buildings; and shall have charge of the erection of both of such buildings.

8. And Resolved Further, That said joint committee shall continue in existence until all of the purpose set forth in these resolutions shall have been fully accomplished.

LETTERS REGARDING THE UNION ENGINEERING SOCIETY HOUSE.

Since our last issue went to press, we have received the following additional letters regarding the proposed Union Engineering Society House, most of them in answer to our circular letter of May 8, addressed to prominent members of the American Society of Civil Engineers:

"It Is to the Interest of the Society to Accept the Plan."

I am strongly of the opinion that it is to the interest of the American Society of Civil Engineers to accept the plan for the joint location of the National Engineering Societies and thus avail itself of the generous offer of Mr. Andrew Carnegie. Yours truly

Philadelphia, May 11, 1903. J. W. Ledoux.

"If We Could All Get Together, How Much Better It Would Be."

I have followed the discussion of the Carnegie Building proposition in your journal with peculiar interest, being one of the oldest mechanical engineers and civil engineers of this city. I have always demurred to joining the several societies on account of their peculiar separate views and management. If we could all get together how much better it would be. We all have something to learn, especially from each other. Although most lines are specialized, still they will always clash if there is not a community of interest and advice. Yours truly,

G. W. Birdsall.

Department of Water Supply, Gas & Electricity,
New York, May 14, 1903.

"Would Not Seem Wise for the American Society to Affiliate with the Other Engineering Organizations."

I have read with interest the various papers which have been sent me, and have given considerable thought to the project for a United Engineering Building in New York.

Weighing all the reasons, both pro and con, it would not seem to be wise for the American Society to affiliate with the other engineering organizations in this matter.

The American Society of Civil Engineers has an international reputation, is independent financially, would have nothing to gain, and much to lose by this affiliation.

Yours truly, John F. Wallace.

Chicago, May 12, 1903.

"The Society Should Consider the Ultimate Benefit to all Other Engineering Bodies as Well as Itself."

It seems to me that the offer of Mr. Carnegie to erect a million dollar building for the engineering societies of this country in New York has placed the American Society of Civil Engineers in a somewhat embarrassing position: its investment in its present property is much greater than that of any of the other engineering societies, and it has a building admirably adapted to its use, and one which it would be difficult to dispose of. The refusal of the American Society of Civil Engineers to join with the other engineering societies in an acceptance of this offer might result in defeating the entire scheme, so that the Society should, in my judgment, consider the ultimate benefit to all other engineering bodies as well as itself, before reaching a conclusion. I have not formed a positive opinion as to what this conclusion should be, but hope that the way may be clear without too great a sacrifice, to join in an acceptance of Mr. Carnegie's generous offer.

Yours truly, Nelson P. Lewis.

New York, May 13, 1903.

"I am Still in Favor of a Building Under the Joint Control of the Several Societies."

When the matter of joint construction of Society buildings was up, during and previous to 1895, I was in favor of obtaining Society rooms jointly with other Societies. It then seemed to be that this was the proper thing to do. I realize that the question has changed somewhat since then; that the American Society has a fine building of its own, and, with few possible exceptions, sufficient room for all its needs. I also realize that there are probably many points of detail, that would have to be settled, and with which I am not familiar.

So far as I understand the situation, I am still in favor of a building under the joint control of the several Societies. Respectfully yours,

James H. Harlow.

Baltimore, Md., May 13, 1903.

"I Will Never Believe that the Engineers of This Country Have Not the Business Ability to Avail Themselves of this Great Offer."

To my mind, this offer gives the engineers an opportunity they have never had and probably will never have again. It is too great and splendid an opportunity to be missed. We will not have a Mr. Carnegie on this earth again, or a chance to get a million-dollar building.

My view of the matter is, that the engineers must get together immediately and in no uncertain terms accept Mr. Carnegie's offer in a definite way and plan out promptly how it should be used. I write the above, understanding there are probably a thousand engineers in this country who can see, and some of them will urge, possible difficulties, but what are difficulties for unless they are to be surmounted, and I will never believe that the engineers of this country have not the business ability to avail themselves of this great offer, in order that they, and their successors may be established in all respects as engineers should be.

While much might be added to what I have already said, it seems to me quite unnecessary to say more at present.

Yours truly, Thos. Rodd, Chief Engineer.

Pennsylvania Lines West of Pittsburg,
Union Station, Pittsburg, Pa., May 18, 1903.

"An Excellent Thing to Have All the Societies Under One Roof."

I have not had an opportunity for consultation with many members of the Society as yet, and in a sense my final opinion is not yet fully arrived at. As the matter strikes me now, it would be an excellent thing to have all the societies under one roof, provided each would have their own individual quarters, and further that these quarters were large enough to accommodate not only the present-sized Societies, but would allow for the expansion which must inevitably come during the next fifty years. The building should also have auditoriums and such accessories as would provide for conventions and other occasions requiring more space than would be provided for ordinary meetings.

The location of the present American Society House is not nearly as desirable as the proposed location, and I believe that in its present quarters the American Society has not all the room required. The tendency to centralization around what might be called the hotel and railway centers has shown itself since the purchase of the present building site, and it looks to me like an excellent opportunity to correct the mistake and at the same time to give the society the additional accommodation which it undoubtedly requires.

What reasons there may be against the acceptance of Mr. Carnegie's offer, I have yet to learn and will reserve judgment until such time as the opponents of the proposition, if there are any such, may have an opportunity to advance their reasons. Very truly yours,

John F. O'Rourke.

Park Row Building, New York, May 12, 1903.

"An Intimate Contact with Other Organizations Would Be Productive of Healthy Stimulation and Advancement."

In replying to your inquiry it seems natural to consider the most salient objections which might be urged against the suggested plan by its opponents, to wit: It might not meet the future requirements of the Society. It might create adverse business and management complications. It might operate towards the submergence of the identity of the Society.

Not only the present, but the future status of the Society must be considered—with a long look ahead—from the standpoint of its expansion. If the suggested change in quarters meets this requirement as fully as the existing home of the Society, then one objection to the change is silenced.

Under existing conditions the business administration of the Society, through being free from complications with other organizations, is reduced to its simplest form and therefore its propriety is entirely dependent upon the wisdom of those to whom this part of the affairs of the

Society is entrusted. If, as seems highly probable, a plan can be matured whereby we shall be insured exemption from any handicap, through adverse business complications arising from the suggested plan, then another objection is removed. In any event, adverse conclusions should not be reached upon the mere statement of a possibility unreduced to a probability.

The fear that the Society would suffer through a loss of prominence arising from close business association with the other national engineering societies is not well founded. If our Society is dependent upon its background for its value, influence and perspective, the sooner it appreciates the fact, the better for its future. On the contrary, I believe that an intimate contact with the other organizations would be productive of healthy stimulation and advancement. Yours very truly,

L. Y. Schermerhorn.

Mariner and Merchant Building,
Philadelphia, May 18, 1903.

"Would Endow an Engineering Publication Fund Instead of a Building."

My own idea is that a more substantial benefit to the engineering profession would result by utilizing this amount of money in another direction. I would suggest that the $1,000,000 form an endowment fund, the interest of which should be devoted to the publication of detailed descriptions of prominent engineering works. For this purpose I would advocate a competent staff of engineers—supplemented by a force of draftsmen, photographers and clerks—which would visit in person such works in progress as were deemed especially worthy of record. I think a personal examination of this kind would develop matters of fact, methods and practice oftentimes overlooked, especially that of cost, an item nearly always wofully neglected in nearly every description of engineering work. The resulting data thus obtained to be published at regular intervals, say every week, as monographs. In this connection it might prove feasible to publish these monographs as supplements to some reputable engineering periodical, for instance, the Engineering News, a reasonable charge, of course, being made for the same.

There is no doubt that this scheme would be opposed by the publishers of the engineering journals as being in competition with their interests and possessing a decided pecuniary advantage derived from the endowment, but it is likely that some arrangement of co-operation could be entered into which would prove of mutual benefit. Of course, not having any very great practical knowledge of the publishing business I could not tell how far, say $40,000 a year, would go. Yours very truly,

Emile Low.

Buffalo, N. Y., May 15, 1903.

"Would Greatly Increase the Usefulness of Each Society."

Your circular of May 8 is duly at hand as to a union building for engineering societies in New York city, made possible by the recent magnificent and generous offer of Mr. Carnegie, and as to my opinion regarding the action which should be taken by the American Society of Civil Engineers regarding such offer.

It appears to me that the American Society of Civil Engineers would be very derelict to the interests of the engineering profession if it did not meet Mr. Carnegie promptly in this matter and do all in its power to hasten the object for which the offer was made.

I think that such a union building, properly established and used, would increase very greatly the usefulness of each society.

I should like to see their libraries consolidated under a single librarian, being kept separate only so far as necessary to preserve the original individual ownerships; but with the future purchases so divided amongst the societies as to avoid future unnecessary duplication of copies.

I should like to see their general meetings and popular lectures so arranged as to be free to all the members of the combined societies and as to allow of an easier preparation and delivering of lectures and of a better acquaintance between such members.

I should like to see their publications so arranged as to allow of sale to any member of the combined societies, at the mere cost of printing.

I should like to see a single engineering society co-ordinated like a university, with all needed facilities for its detailed work in separate branches, but arranged so that it will easily act as a unit in matters of general interest or of semi-public or popular nature.

It would seem to me that a single building for the joint use of the societies as a combined engineering society and club with minor subdivisions of libraries, lecture plant and other features special to each prominent branch of engineering knowledge would reduce cost or increase facilities in matters of engineering research, work and distribution of information, or perhaps do both, in a manner and to an extent which would greatly benefit the general progress of engineering knowledge and give increased standing and reputation to the engineering profession as a class or whole. Very truly yours,

W. H. Bixby, Major, Corps of Engineers, U. S. A.
Engineer Office, U. S. Army, Detroit, Mich, May 13, 1903.

"The Societies Would Lose Their Individuality in the Public Mind by Being Grouped Together."

Your request for an opinion as to what should be the attitude of the American Society of Civil Engineers with reference to Mr. Carnegie's offer to erect a building in New York city for the engineering societies is before me. There are no doubt some valid arguments in favor of such a proposition. For my own part, it does not seem to be always best for a society or a community to relinquish the exertion, the activity necessary to its vigorous growth, and fall back on the hand of charity for its sustenance. The simple act of doing for ourselves, strengthens our being; while the opposite course of depending on others debilitates and weakens.

The field of engineering has grown so great and the work of the engineer has become so diversified that no single individual in these days of rapid progress can hope to cover more than a small portion of the science of engineering. Hence there is need for and must always be several societies covering the various fields of engineering effort.

The proposed building would probably become the home of technical societies more or less closely related to engineering and the societies occupying the same would largely lose their individuality, in the public mind at least, by being grouped together.

The American Society of Civil Engineers has its own home which is well suited to its requirements; it is in good condition financially; its influence in the country at large is perhaps equal to if not greater than any similar organization; it stands for honor and integrity in the engineering profession and its members are loyally devoted to its success. It has a mission of its own to perform which it cannot share with other societies; it cannot afford to obscure its identity and on the whole it is apt to lose far more than would be gained by joining in the movement to combine the engineering forces in one great building. Independence is quite as essential as union and it is not incompatible with such co-operation with other societies as may be found desirable.

Very respectfully, J. A. Ockerson.

Fullerton Building, St. Louis, Mo., May 13, 1903.

"Such an Arrangement Would Have Decided Business Advantages."

This proposition appeals more to the members of the societies who are familiar with their business and social interests than to those whose touch has been only with their technical or scientific interests. Speaking as a member of the American Society of Civil Engineers, although I have been a member for more than 28 years, I have seldom attended its business meetings, and do not feel competent to express an opinion upon the merits of the Carnegie offer from a business point of view.

No objection can be made to the object of Mr. Carnegie to provide a grand building for all the engineering societies. Such an institution would be somewhat like the Cooper Union, which for many years has been a vast benefit not only to the people of New York, but to the entire Union.

If the object is not to merge the societies, but only to provide a building for joint, and, as it were, at the same time independent use, or one building for all rather than a separate building (as at present) for each, doubtless such an arrangement would have decided business advantages, and a board of trustees made up from each society could conduct the occupation of the building so as to avoid friction and just complaint from any society.

The proposed merging of the libraries might or might not be advantageous. At present it appears to me that if there be any material in the library of our Society which members of the other societies might wish to examine, there should be no objection to allowing the use of it under any reasonable regulations with reference to the care and return of documents; although if the libraries of the several societies were merged it would facilitate its use by all members of each.

Considering the auditorium or convention hall of the building, there should be no difficulty in arranging for the use of this by each of the societies in turn without objection from the others.

Speaking with reference to the donor, every member of each society must feel profoundly grateful for his liberal offer, and should ever hold Mr. Carnegie in kind remembrance. Certainly his tender of this large sum for a society building, so far as I am aware, is without parallel, and the very magnitude of the offer is bound to command the respect and admiration of every member of each society. Yours truly,

John W. Hill.

710 City Hall, Philadelphia, Pa., May 16, 1903.

"The Acceptance of the Gift Will Be for the Decided Advantage of Civil Engineers."

The acceptance of Mr. Carnegie's splendid gift, by the American Society of Civil Engineers, should be viewed from the standpoint of the ultimate good of the membership body, and that view should not be clouded by any financial consideration or sentiment of exclusiveness. There are undoubtedly two sides to the question, but it seems to me that the acceptance of the gift will be decidedly for the advantage of civil engineers, ultimately, if not almost immediately.

The Society affords a medium for the exchange of information pertaining to current operations and personal experience. It also offers an opportunity to develop the social life inside of and peculiar to the profession. It gives us almost the only opportunity we have to know each other. In both of these respects it seems to me the American Society will be the gainers by the change. Very many able men whom most of the members of the Society have now little chance of meeting, will be added to the throng that will come from week to week for profit or for pleasure, to this, the greatest of all engineering centers. The fact that the club contains in its membership some that are not engineers, and that some of the other societies admit members under a standard quite inferior to that of the American Society, does not detract, it seems to me, from these advantages. For one, I should greatly regret to see any lessening of the high standard of membership now required by the Civil Engineers, but if I understand the plan proposed, the perfect independence of the organization is provided for and this high standard may still be maintained.

Mr. Carnegie's gift is so great that the American Society may be better off financially if it is accepted even though it should sacrifice considerably in the depreciation of the property it now possesses; but even if that does not prove to be the case, it seems to me the consideration of that financial disadvantage ought not to weigh materially in the decision of the Society as to what it shall do.

The Society exalts and dignifies the profession of the civil engineer and makes the work of the individual valuable in the eyes of the world. It does this by insisting on the high standard of character and professional ability in its members, but it does it also by the power and the influence of a large membership, a creditable home, the possession of all things needful and the dignity of its functions. It seems to me, in the plan now proposed that there will be a material advantage in all these latter things. The power and influence of the profession as a whole will be magnified, and the great world outside will have the importance of the engineer as a professional man thrust upon it, so to speak, by all these outward evidences. This means a greater appreciation of its services, and, ultimately, increased compensation for them. I feel, therefore, that it would be a real calamity if any of the bodies named should stand in the way of the most perfect fulfilment of the plan as outlined. Yours truly,

Corydon T. Purdy.

78 Fifth Ave., New York, May 18, 1903.

TRIANGULATION OF NEW YORK CITY AS A BASIS FOR A TOPOGRAPHICAL SURVEY.

The city of New York has never had a comprehensive and accurate survey. A beginning was made years ago in some triangulation work between a number of stations in Brooklyn and Queens county, and some stations in Manhattan Island, Staten Island, and the present borough of the Bronx. At one or two points this network of stations touched the secondary triangulation of the United States Coast and Geodetic Survey; many observations of angles were made and approximately adjusted and some topographical work was based on them. The entire work up to date has been only fragmentary, and, moreover, since it formed no comprehensive system and was carried on by different methods at different times, it was not suited to form the basis of a complete survey system.

The charter of Greater New York, drawn up at the time of the consolidation six years ago, provided for a survey of the city, to be conducted by an engineer experienced in precise surveying who shall have qualified by a civil service examination. In the new charter adopted two years ago this clause was changed to the effect that a complete survey of the city was to be made under the direction of an officer of the United States Coast and Geodetic Survey, according to the methods approved by that bureau for such work. Accordingly, the city of New York, through its Board of Estimate and Apportionment, Mr. Nelson P. Lewis, Engineer, has arranged with Mr. O. H. Tittmann, Superintendent of the Coast and Geodetic Survey, to carry out a triangulation of the area covered by the city. Mr. A. T. Mosman, M. Am. Soc. C. E., Assistant, U. S. C. & G. S., has been detailed to conduct this triangulation, and has just taken up the work; it is expected that the larger part of the field work will be completed during the present season.

The triangulation planned by Mr. Mosman will utilize as base-points the available stations of the secondary triangulation network of the Coast and

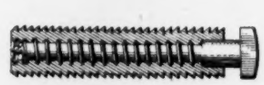
Geodetic Survey. These, in conjunction with other stations to be established at suitable points, will form a network of maximum or primary triangles stretching across the area to be covered. The sides of these triangles will be from five to fifteen miles in length. The methods of observation will follow as closely as possible the method used by the Coast and Geodetic Survey in secondary triangulation (to which the present work corresponds) with only such variations as are made necessary by local conditions. From this primary network a large series of secondary triangles will be extended for the purpose of fixing points, over the whole area, from 5,000 to 15,000 ft. apart. The establishment of these points will terminate the work at present in hand, that is to say, the triangulation of the city.

The degree of accuracy which has been established for the entire system of triangulation is 1 in 25,000. This is slightly less than the accuracy of the secondary work of the Coast and Geodetic Survey (1 in 40,000). It is probable that the primary angles will be measured with large, say 10-in., repeating transits, and it is likely that heliotropes will have to be used, as the average atmosphere over the city is anything but clear. The arrangements made in regard to the cost of the work are interesting. The observing will be done by men furnished by the city of New York under Civil Service rules. The computing is to be done at Washington, under the direction and according to the methods of the U. S. Coast and Geodetic Survey, by computers furnished by the city of New York. The Coast Survey furnishes and pays the director of the work (Mr. Mosman), and in return for this service the Coast Survey will receive a copy of the notes, computations and results of the work. All other expenses of the work are borne by the city. It is evident, of course, that the fact that no base-lines have to be measured, and no latitudes, longitudes or azimuths to be determined (all these being given by the U. S. C. & G. S. lines), will make a great economy in the cost of the whole work.

A NEW LAG SCREW EXPANSION BOLT.

We illustrate herewith a recently patented expansion bolt. It is especially adapted to use as a timber fastener, and in a way resembles the well-known "plug and feathers" used in quarrying, the two feathers being replaced by the two serrated sleeves C, C, and the plug being replaced by the lag screw E. The serrated sleeves are

Elevation



Section.

A New Lag Screw Expansion Bolt.

slipped into the hole bored in the wood, and the lag screw is screwed into the threads on the inner face of the sleeves, thus expanding them so that their serrations grip the wood. It appears to us to be a simple and effective method of securing a good fastening to timber.

The bolt is made by the Steward & Romaine Mfg. Co., 124 North Sixth St., Philadelphia, Pa., Mr. N. H. Steward of the firm being its inventor.

THE LIGHT DRAFT RIVER TUG "JAMES RUMSEY."

In our issue of March 19, we briefly noted a remarkable "tug-of-war" on the Kanawha River at Charleston, W. Va., between an old-fashioned stern-wheel tow-boat and a new screw propeller vessel, in which the latter was victorious.

As our readers doubtless know, on the Ohio River and its tributaries the stern-wheel steamer has long been the standard type of vessel, particularly for towing work, or rather pushing, since a large part of the traffic on these streams is conveying coal, lumber, etc., down stream. A single tow-boat will handle a whole fleet of coal barges. It is secured to the rear of the fleet and guides them down stream around sharp bends, chiefly by holding them back at the proper time while the current swings them into the proper direction.

To use a screw-propelled vessel on such streams with their very shallow depth is a notable innovation, and the new screw vessel, which is christened the "James Rumsey," has attracted much attention.

The "James Rumsey" was designed and built by the Ward Engineering Works, of Charleston, W. Va., for the U. S. Engineer Corps, for use in the improvements of the Ohio and Kanawha rivers, for towing the government craft—dredges, etc. Her length is 120 ft.; beam, 22 ft.; depth, 4 ft. 6 ins.; width over guards, 24 ft.; displacement without load, 100 tons; draft, 32 ins. aft, 24 ins. forward. The rudders and steering gear are all of steel. The hull is of steel divided by four athwartship bulkheads, making five water-tight compartments, and there are two longitudinal steel-plate bulkheads extending the full length of the boat.

The machinery department, Fig. 2, occupies the middle compartment, which is 33 ft. long. On either side are coal bunkers with a capacity for 40 tons, equal to steaming 1,000 miles at 10-mile speed. The boiler, Fig. 3, is the Ward Sectional Coil-Boiler, which has been used in the U. S. Navy. It has 50 sq. ft. of grate surface, 1,650 sq. ft. of heating surface; and is designed for 250 lbs. steam, although 220 lbs. only is carried. The machinery consists of a pair of Ward two-crank quadruple-expansion engines, 7, 10, 14, and 20 ins., and 12 ins. stroke. They are designed specially for this work, having link motion, steel frame, steel crosshead with slipper guide, and piston valves throughout. The air pump is simplex vertical light weight; and the feed pump is of the duplex type, with outside packed plungers; sectional outboard condensers are used, one for each engine. The condensers are arranged on the sides of the boat, which may be listed to make repairs. The twin propellers are four-bladed, 4 ft. 3 ins. diameter, and are placed in tunnels; the lower edge of the propellers being slightly above the bottom of the boat, so when at rest the blades extend 21 ins. above the general surface of the water. Manhole plates over the propellers admit of their being changed or removed without docking the boat.

The contract requirements as to I. HP. were 425, but indicators have shown a maximum, with boat in free course, of 550 I. HP.

The "Rumsey" was designed with special regard to towing, both pushing and backing, to supersede the old stern-wheel tow-boat, which handles such tremendous fleets of coal in barges, which they guide down stream mostly by holding them back while the current swings them into proper direction, when the push ahead again until it again becomes necessary to check up to keep the fleet in proper course.

The "Rumsey" backs and steers 75% as much as she pushes, while the stern-wheel "Lane" backs from 50% to 60% of her pushing power. The former was demonstrated by scales, the latter estimated by comparison with the "Rumsey."

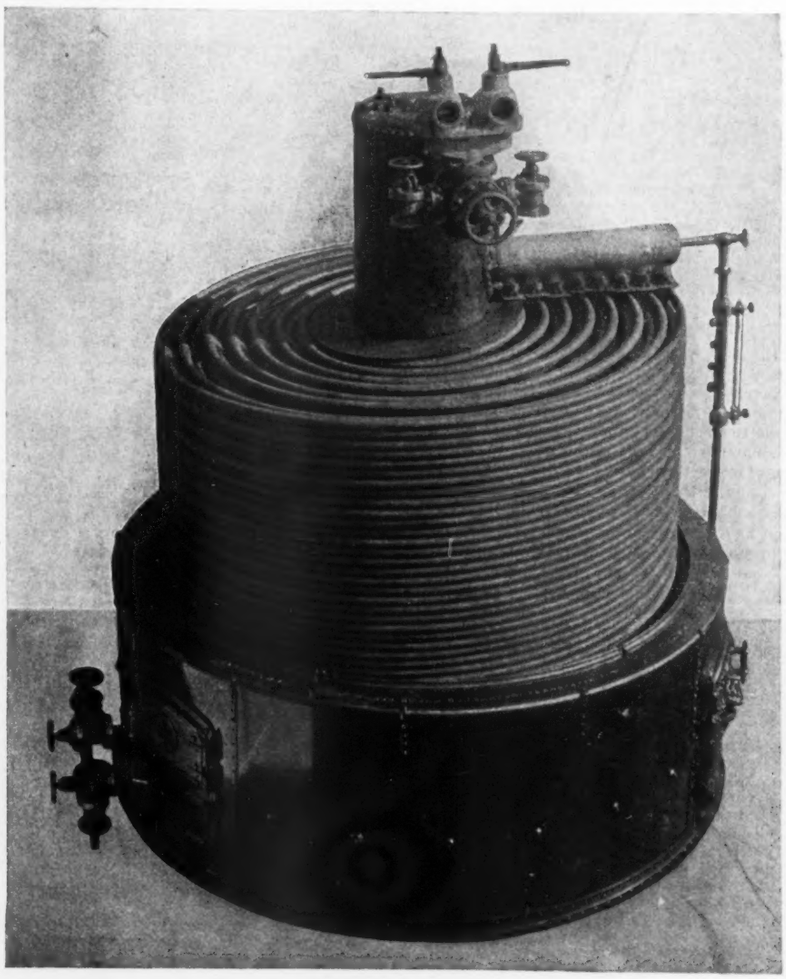


FIG. 3. WARD SECTIONAL COIL BOILER.

The draft of the "D. T. Lane," it should be added, is 51 ins.

The "Rumsey" was designed by Mr. Charles Ward, M. Am. Soc. M. E., of the Ward Engineering Works, Charleston, W. Va., to whom we are indebted for the accompanying cuts, and for a description of the design.

The spectacular tug-of-war above referred to was arranged between the "Rumsey" and the "D. T. Lane," a stern-wheel tug-boat, owned by the Campbell's Creek Coal Co. The "Lane" has cylinders 16 ins. in diameter and 5 ft. 6 ins. stroke, working directly on the stern wheel shaft in the usual manner. Her draft is 51 ins., whereas the "Rumsey" draws only 32 ins., and the hull has about double the displacement.

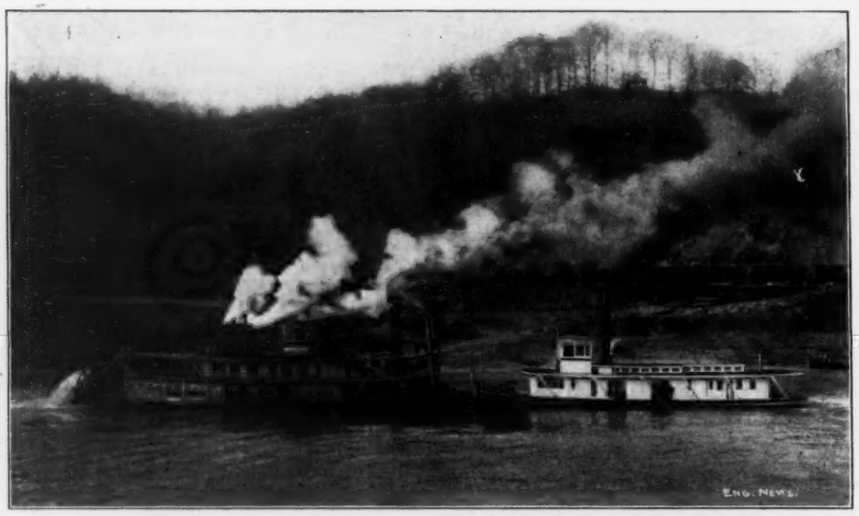


FIG. 1. "TUG-OF-WAR" BETWEEN THE "JAMES RUMSEY" AND THE "D. T. LANE."

In the first test the two boats were lashed together at their bows and each tried to push the other. The result was that the "Rumsey" pushed the "Lane" upstream a distance of about 60 ft. against the combined force of the "Lane's" machinery and the current of the river. In the second series of tests the engines of each boat were reversed, and in this the superior power of the screw propeller boat was even more evident.

STRENGTH OF WHITE-IRON CASTINGS AS INFLUENCED BY HEAT-TREATMENT.*

By A. E. Outerbridge, Jr.†

In the year 1882, while engaged in metallurgical work at the car-wheel foundry of A. Whitney & Sons, in Philadelphia, my attention was called by the inspector of wheels to an unusual and remarkable change that had occurred in the chilled or white iron forming the "treads" of a number of wheels poured from one heat. This change was first observed on removing the wheels from the annealing ovens. It was customary for the inspector to prove the hardness of the chilled treads by testing them with a cold chisel all around the "throat" or place where the tread joins the flange. On this occasion he found a number of wheels which were quite soft on one portion of the rim, extending the entire width of the tread for a length of 6 or 7 ins., while on either side of the soft spots the chilled tread was so hard that the steel chisel slipped over the surface without biting. In order to study the nature of this singular occurrence I caused the wheels to be broken through the soft spots so as to examine the fracture, and I found that the white iron (chilled iron) had been changed into perfectly gray iron, evidently after the wheels had been cast. The change was not equally well marked in all of the wheels and the soft spots were smaller in area in some cases than in others, but in all, the dividing line between the white portion and the gray portion of the chilled tread was sharply defined.

It is perhaps necessary to state that in the establishment where these wheels were cast it was customary to pre-heat the annealing pits by means of soft-coal fires before the wheels were lowered into them, the flames passing through the pits or ovens. The rule was to close the dampers just before the pits were opened to receive the red-hot wheels, in order to shut out the flames.

After careful investigation, I found that through an oversight the dampers of the annealing pits had not been closed and the flames from the fires impinged upon the surfaces of three or four red-hot wheels in the lower part of each pit, causing a complete change of the carbon from the combined form to the free condition wherever the flames touched the castings.

Drillings were taken for analysis from the soft parts of the chilled treads and also from other parts of the wheels, as well as from test-pieces poured from the same ladles of iron. The analysis showed two things—first, that the car-wheel iron was of normal composition; second, that the only change in the metal of the annealed or soft portion of the "chill" was in the condition of the carbon, which had been converted from chemical combination with the iron into an amorphous form of graphitic carbon, or, to speak more guardedly, I would prefer to say simply into the form of "free" carbon, for there are reasons for believing that the carbon in this case is not in the same condition as when it exists normally in gray iron.*

Specific-gravity tests showed that the gray cast-iron resulting from this accidental heat treatment of white iron differed materially in density from the normal gray iron forming the unchilled parts of the same castings; the specific gravity was about 7.80 as compared with specific gravity of about 7.20 for the normal gray metal; a cubic foot of the gray iron produced by this annealing process therefore weighed about 37.5 lbs. more than a cubic foot of the normal gray iron of the same casting. It was noticed that the fracture was of much finer grain than normal gray iron, and "chips" or drillings of the annealed chilled iron differed greatly in appearance, size and shape from the chips or drillings of the normal gray iron made with the same drill.

Several metallurgists, to whom the pieces of annealed chilled iron were exhibited, offered a plausible explanation of the phenomenon, saying that it was merely an accidental conversion of the white iron into malleable iron, and therefore presented no novel features. The analyses quickly showed the fallacy of this theory, for the total carbon was the same after annealing as before annealing, being about 3½% in each case, while in the ordinary conversion of white-iron castings into malleable iron, a large part of the carbon is removed by the oxidizing material in which the castings are imbedded when subjected to heat-treatment, and this conversion of white iron into malleable iron can only be successfully accomplished on sections of metal of moderate thickness, say less than 3 ins.

Although this accidental discovery of annealing of white iron on the treads of car-wheels was regarded as an interesting and novel one at the time, the only practical use made of it was to guard against a repetition of the accident in the annealing pits of the car-wheel works with which I was at that time connected.

After the lapse of several years I was called upon to investigate in a professional capacity, and in the interest of some prospective investors, the merits of a new process of converting white-iron castings into steel, and received from the manufacturer a number of axes, hatchets and other edge tools, which had been cast in white iron and subsequently converted into a metal having evidently many of the qualities of steel.

Without describing in detail the process to which these white-iron castings had been subjected, I may say, briefly, that they were placed in the muffle of a furnace together with a chemical compound claimed to be necessary to the conversion of the cast-iron into steel. Common salt and crude hydrochloric acid were two ingredients of this compound. The similarity between this process and the accidental over-annealing of the car-wheels (with consequent change of the condition of the carbon) suggested to my mind that the chemical compound was probably unnecessary and that the secret consisted solely in the heat treatment, and I so advised my clients.

The conversion of white-iron castings into dense gray iron having high tensile strength (approximating that of certain grades of steel) capable of being hardened and of taking a sharp cutting edge is no longer a secret, and is carried out on a commercial scale in a number of establishments. While I cannot speak positively, I am of the opinion that the heat treatment alone is now relied upon to produce the desired results. These products are not steel castings, though sold in some instances under the name of steel; neither are they malleable iron, but they may be described as occupying a peculiar position midway between cast-steel and cast-iron.

Having given a resume of the history of this process of heat-treatment of white-iron castings, I will state a few facts regarding certain interesting features, including tensile strength of this converted metal. In the early experiments I found that there was a vast difference in white irons, some samples remained white and hard after having been soaked for many days in the annealing furnace, even when subjected to the highest temperature below the melting point of the metal, while other specimens of white iron of the same dimensions yielded readily to the heat-treatment and became completely converted into gray iron in a few hours at a comparatively low temperature—analyses of the different samples revealed the chief cause of this difference; it depends almost entirely upon the presence or absence of silicon in the white iron; castings containing only a trace (or a few tenths of 1%) of silicon cannot be successfully treated, for only a partial change of the combined carbon into free carbon takes place, even after prolonged treatment at the highest temperatures. Thus, in one of my tests, two white iron bars, about 2

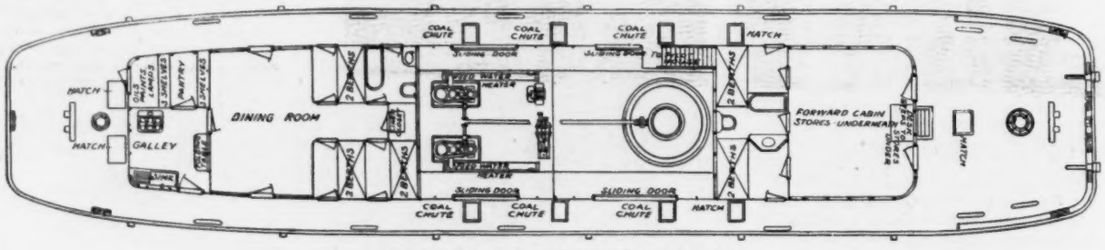


FIG. 2. PLAN OF THE "JAMES RUMSEY."

*A paper read at the fifth annual meeting of the American Society for Testing Materials, held at Atlantic City, June 12, 13, 14, 1902, and published in the Proceedings of the Society for 1902.

†Chemist and Metallurgist, 1600 Hamilton St., Philadelphia, Pa.

*Through purely chemical methods four conditions have been detected: (1) Graphite or free crystallized carbon, not acted on by acids even when concentrated. (2) Graphitic carbon or "temper-carbon," which is also in a free state and unaffected by acids, but presenting an amorphous appearance. (3) The carbon of the carbide of iron (cement carbon) forming a definite compound, acted upon by concentrated acids, but insoluble in diluted cold acids. This carbide answers to the formula Fe_3C. (4) Hardening carbon, which appears to form a solid solution with the iron (or which is perhaps present as a compound dissolved in the iron) and which is acted upon by cold, dilute acids. "Notes on the Chemical Constitution of Cast-iron and Steel." By A. Carnot and E. Coutal, "Annals des Mines," October, 1900.

ins. in diameter and 12 ins. long, were placed side by side in the furnace and subjected to the heat treatment for 8 hrs. One of the bars, containing about 0.15% silicon, was cast in sand; the other, containing 1.25% silicon, was cast in a heavy iron mold, because, if cast in sand, it would not have been white iron. Both bars were equally brittle, equally hard, and perfectly white before treatment; a slight tap with a hand-hammer was sufficient to break them. When removed from the furnace after 8 hours soaking at a high heat, and allowed to cool in the air, the bar containing 0.15% silicon was unchanged in the appearance of the fracture, while the bar containing 1.25% silicon was almost gray; it was soft and so ductile that a small piece of it was flattened out under the steam-hammer while cold. The bars were then returned to the furnace, subjected to the same heat treatment for 6 hours longer and allowed to cool as before. No visible change occurred in the low silicon bar, while the other bar was completely converted into gray iron with a uniformly fine grained fracture and dark gray color. This bar was turned in a lathe to a diameter of 1.129 ins. (giving an area of 1 in.) and provided with threaded ends for the grips of the testing machine. The metal was readily machinable and the surface was free from "graphite pits" so characteristic of ordinary soft gray iron when machined. This bar was pulled on a hydraulic testing machine of 100,000 lbs. capacity, and the actual load at failure was 47,760 lbs. The elongation and reduction of area were not measured, but were very small.

A number of similar tests were made on different sized bars, giving tensile strengths ranging between 40,000 and 50,000 lbs. per sq. in., but manufacturers equipped for making converted castings in this way have obtained much higher records than these.

The literature upon this novel and interesting subject is very limited, but some valuable papers have been published and it is my desire to present herewith a resume of the work done by several well-known metallurgists in this country and in Europe.

At the meeting of the Mining and Metallurgical Section of the Franklin Institute held June 9, 1897, Mr. Charles James described "A Special Process for Treating Cast-Iron,", the following account of which appeared in the "Journal of the Franklin Institute" of July, 1897:

White iron, with approximately 2.40% combined carbon and 0.4% graphitic carbon, is used for the purpose. The castings are placed in a muffle furnace, in which they are subjected to the action of a secret composition (said to be a powerful volatile oxidizing agent) and maintained at a temperature slightly below fusion for five or six hours.

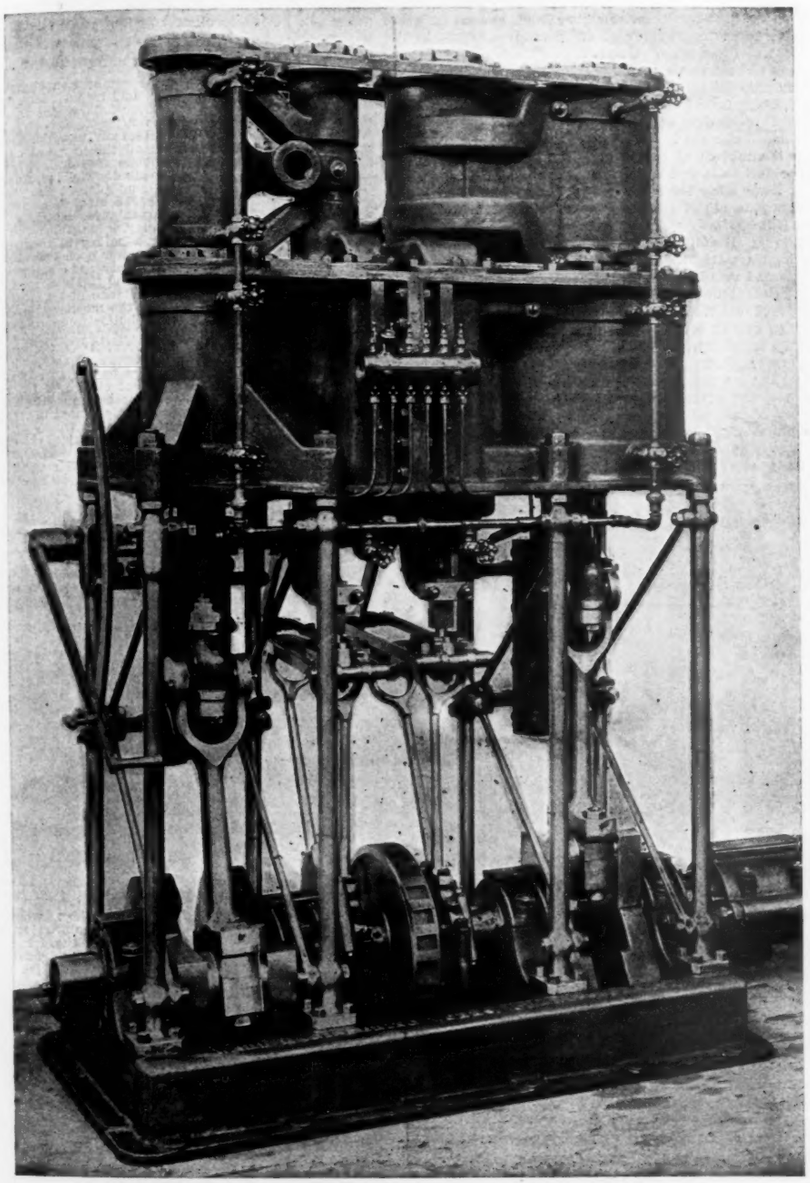


FIG. 4. WARD TWO-CRANK, QUADRUPLE-EXPANSION ENGINES.

The product may be forged and tempered and shows a remarkable increase in tensile strength. The total carbon in the product seems to be the same as in the untreated iron, but combined carbon has been substantially altered into a finely disseminated uncombined carbon.

Doubts were expressed in the discussion which followed, whether the result was not due entirely to the annealing, rather than to the "medicine." The prolonged annealing was thought to be a sufficient explanation of the facts. The process is in commercial operation in a large foundry in Philadelphia, producing hatchets, hammers, etc.

The "Journal of the Franklin Institute" for September, 1900, contains an article by Mr. James on the subject, giving abstracts of results obtained from daily business practice, extending over a considerable period of time; but though these investigations were made for the guidance of commercial operations, they seem to be of sufficient metallurgical interest to justify their presentation. Mr. James states that the irons used were all of Bessemer quality, the melting charges consisting of a mixture of gray and white irons, of which the following is an average analysis:

	C.C.	G.C.	Si.	Mn.	S.	P.
White iron	3.50	0.50	0.50	0.20	0.08	0.08
Gray iron	.50	3.50	1.30	.30	.02	.03

The composition of the charges was regulated by the silicon content, which was made to vary from 1.20% to 0.90 of 1%, the average chemical composition of these mixtures being:

	Per cent.		Per cent.
Carbon	3.40 to 3.80	Sulphur	0.05 to 0.04
Silicon	.90 " 1.20	Phosphorus	.04 " .03
Manganese	.35 " .20		

The iron was sometimes smelted in a cupola, but generally in an air-furnace. The following is the average chemical composition of a large number of castings:

C.C.	G.C.	Si.	Mn.	S.	P.
3.02	0.47	0.78	0.12	0.05	0.04

The weight of the castings ranged from a ½-oz. to 2,000 lbs. and over. The time required to effect the change varied from 3½ to 10 hrs. from the time the castings had attained their full temperature.

The temperature at which the change takes place in castings of this description lies between the melting point of silver and copper, and may therefore be approximately taken at 1,850° F.

The change of carbon in castings subjected to the annealing process, though gradual, is co-extensive throughout any given cross-section of the casting; no hard center or core of white iron surrounded by softer metal, having ever been observed in any of the castings examined. No matter at what period the annealing may have been arrested, the total surface of any fracture always showed a similarity in the condition of the metal, provided the composition of the metal was homogeneous and the heat treatment had been applied equally to all parts of the casting.

This agrees perfectly with my own observations, and it constitutes, moreover, a very interesting and important feature, differing from malleable iron castings, where a progressive change occurs; the central portion of a malleable iron casting is sometimes found to be practically unaffected by the heat treatment as to the total carbon, and unless the casting is very thin, the conversion is in fact never uniform throughout the section. The same law of progressive change in the proportion of carbon obtains in "case-hardening" of steel, though the operation is the reverse, i. e., carbon is imparted to, instead of withdrawn from, the metal.

The following analyses before and after annealing, given by Mr. James, show very clearly, that the only change effected by the heat treatment is in the condition of the carbon:

	C.C.	G.C.	Si.	Mn.	S.	P.
Before annealing ...	2.60	.72	.71	.110	.045	.039
After annealing	.82	2.75	.73	.108	.040	.039

Mr. James says:

I wish, however, to say that, although for convenience, the term graphite is employed in stating the analyses of these castings after annealing, the condition of the carbon differs very materially from graphite, either as found free in nature or as solidified out from gray iron during cooling. . . . The carbon thus formed is evidently identical with what Ledebur has called "tempering graphite carbon," and is an allotropic form of graphite, and not merely amorphous carbon.

Mr. James states that both silicon and manganese exert great influence upon the carbon during the annealing process.

The presence of silicon being a necessary condition to the carbon change. In low silicon iron it is very difficult and in some cases impossible, to effect the carbon change, no matter how long the iron is exposed to the heat treatment.

My original investigations did not indicate that manganese possessed any very marked influence on the carbon change in this process, though I am well aware that manganese, especially in the form of ferro-manganese, added in very small quantity to molten car-wheel iron, exerts a marked effect upon the chill and on the relative proportion of combined and graphitic carbon. It is a fact, however, that low silicon irons are usually low in manganese, and this, I think, is the reason why Mr. James was led to infer that manganese facilitates the carbon change in the annealing process.

Mr. James gives no records of strength of the white iron castings converted by him into gray iron by annealing.

Before proceeding to the consideration of other features I desire to call attention in passing to one point which may, I think, have practical value, especially in the manufacture of chilled cast-iron car-wheels.

It has long been known that wheels having approximately the same depth of chill on their treads wear very differently in service: some retain their hard surface until the white iron tread is gradually worn away evenly all around the wheel; others become soft in spots very quickly, necessitating removal from service long before the wheel has lived its proper life.

We know that the action of the brakes on the wheel heats the tread, and it seems to me not unlikely, from the foregoing observations, that when the silicon exceeds a certain amount, say, 0.7% in any wheel, a similar kind of annealing of the white iron tread of the wheel may occur from the heating action of the brakes, thus changing the condition of the carbon, at least to a partial extent, causing the chilled tread to become much softer than would happen under similar conditions where the wheel is made of metal containing less silicon.

The most recent investigations bearing upon the subject under discussion corroborate the prior observations fully, and may be found in the "Bulletin de la Societe d'Encouragement pour l'Industrie Nationale," Paris, March 31, 1902, under the title, "Sur l'Equilibre des Systemes Fer-Carbone," by G. Charpy and L. Grenet.

The authors call attention to the investigations of M. Bakhuis Roozeboom on an interpretation of known facts relating to the constitution of metals formed of iron and carbon, published in the "Bulletin de la Societe d'Encouragement," November, 1900, and also to the investigations of Hugh P. Tiemann on "The temperature limits for the separation of graphite from martensite in pure cast-iron," published in the "Metallographist," October, 1901.

The authors say: One can believe, then, as appears to be admitted by Mr. Tiemann, that the abundant separation of graphite, observed by Mr. Roynton, was due to the presence of silicon in the white iron castings employed.

We have made a great many experiments on this point, and we direct attention in particlar to the results obtained on five samples of iron containing practically the same percentage of total carbon, and in which the other elements are found only in small proportions, except the silicon which exists in variable quantities.

The following table gives the composition of these specimens:

	Carbon.	Silicon.	Manganese.	Sulphur.	Phosphorus.
No. 1	3.60	0.07	0.05	0.01	Trace.
No. 2	3.40	0.27	Trace.	0.02	0.02
No. 3	3.25	0.20	Trace.	0.01	0.03
No. 4	3.20	1.25	0.12	0.01	0.01
No. 5	3.30	2.10	0.12	0.02	0.01

These samples had been poured into cold water and did not contain any appreciable proportion of graphite, except the last, where we found 0.20%. Fragments were subjected to annealing, more or less prolonged, at different temperatures. Six tables are given showing the length of time of each treatment, the exact temperatures, and the proportionate change of combined carbon into graphite for each specimen.

The following conclusions are reached: They are announced didactically as laws and may be so accepted.

(1) The separation of graphite commences at a lower temperature as the percentage of silicon is increased in the iron.

(2) The separation of graphite having begun, it continues at a lower temperature than that required to commence the reaction.

(3) At a constant temperature the separation of graphite proceeds at a lower speed according as the temperature is lower and the proportion of silicon is less.

(4) The proportion of combined carbon which corresponds to the equilibrium at a given temperature diminishes when the silicon is increased.

(5) The brochure of Messrs. Charpy and Grenet is embellished with several fine photo-micrographs showing very clearly the microstructure both before and after treatment. No records are given of tensile strength of the treated specimens and, as it is stated at the beginning of the paper that the white iron specimens were obtained by pouring the metal into cold water, tensile tests could not be made, for the samples were presumably merely small irregular lumps which are far inferior, I think, for such purpose to the uniform ingots of white iron obtained by pouring high chilling metal into heavy iron molds. I have found it easy in this way to obtain ingots of white iron of any desired length and of suitable sections, the dimensions depending, of course, upon the proportion of silicon contained in the iron poured. By using a flat ingot mold made of thick cast-iron plates I have obtained flat ingots $5 \times 3 \times \frac{1}{2}$ ins. of perfectly white iron and containing as much as 2% of silicon. These high silicon white iron ingots or plates are very readily converted into gray iron by annealing.

Although I consider it a misnomer to call castings, such as hatchets, axes, etc., made from white iron changed to gray iron by heat treatment and subsequently hardened on cutting edges, steel castings, they are certainly very different from true malleable iron castings or from ordinary gray iron castings, possessing qualities more closely resembling steel.

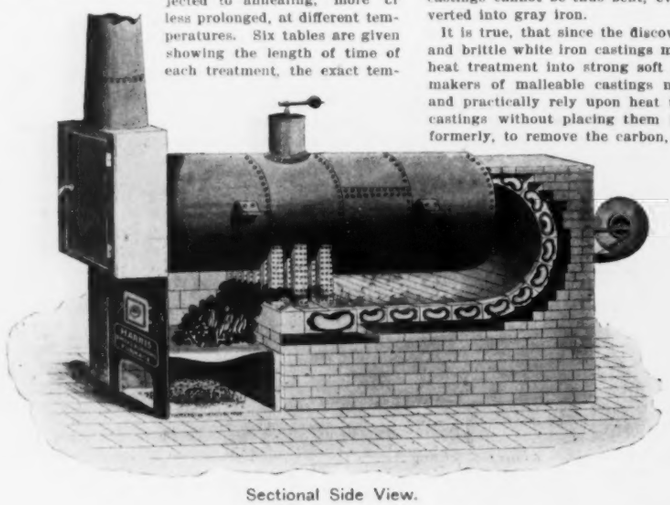
When the process is carefully and intelligently conducted the product is reliable, but prejudice has been developed by the fact that some of the manufacturers have not thoroughly understood the underlying principles and have turned out castings imperfectly converted. It is, of course, much easier to make perfectly white iron castings from metal very low in silicon, but, as I have here shown, such metal is unsuitable for the subsequent conversion by heat treatment into gray iron, and this I believe to be the main cause of many failures.

So far as I know there are no valid patents covering the process of heat treatment of white iron castings for conversion into dense gray iron of high tensile strength, capable of being forged and tempered, by simply changing the condition of carbon without removing any of the original component elements.

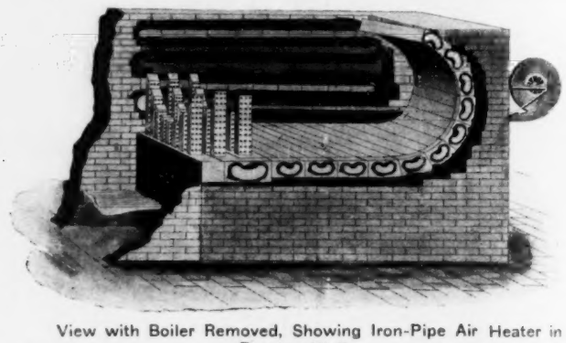
As the process of converting white iron castings into malleable iron is well understood and has been carried out on a large scale for many years, I have not thought it necessary to allude to this product further than to show that it is radically different from the white iron castings containing all of the carbon of the original metal before the heat treatment. Good malleable iron castings are ductile and may be bent almost double and twisted, while cold, without breaking, if the section is light enough to permit of complete malleableizing, but annealed white castings cannot be thus bent, even when completely converted into gray iron.

It is true, that since the discovery of the fact that hard and brittle white iron castings may be changed by simple heat treatment into strong soft gray iron castings, some makers of malleable castings modify their old methods and practically rely upon heat treatment to anneal their castings without placing them in oxidizing material, as formerly, to remove the carbon, but such heat treatment does not and cannot make true malleable iron castings. In other respects, also, converted white iron castings, containing all of the original carbon, differ in physical properties from malleable iron castings from which a large portion of the carbon has been removed.

In conclusion, I would say that if we can eliminate the false name of "steel" which has been given to converted white iron castings, a distinct advantage will have been gained, for I believe that the new metal is worthy of taking a special place in the metallurgical arts, and I anticipate extended practical applications of the process as knowledge of the proper methods of heat treatment and of the valuable properties (as well as the equally marked limitations) of the metal shall become better known and appreciated.



Sectional Side View.



View with Boiler Removed, Showing Iron-Pipe Air Heater in Furnace Wall.

A SMOKELESS COMBUSTION BOILER FURNACE.

J. B. Harris, Nashville, Tenn., Inventor.

simplicity in all devices that pertain to furnaces, if practical success is desired. Both these devices, so far as we can see, should work with a high degree of efficiency, but we are likewise compelled to say that the practical difficulties in their construction and maintenance seem to us insuperable.

They are nevertheless of interest and worth placing on record as notable experiments in boiler furnace construction.

The first of these furnaces is the invention of J. B. Harris, M. D., of Nashville, Tenn., and is intended for use with stationary boilers. It is illustrated in the accompanying cuts, which show the device in connection with a horizontal return tubular boiler. While the idea of the Harris furnace will be made clear to most of our readers by the illustration, we reprint the following extract from a description furnished us by the inventor:

The floor and rear end of the combustion chamber are formed by hollow fire-clay logs laid transversely, through which is a 6-in. hollow, and these hollows are made continuous by end knuckle joints fitted to the ends of the logs, so as to turn the current of air into the next contiguous log, and continues till all the logs are connected and the hollows made continuous to the last, the terminal end in last log closing blind. The last three fire-clay logs at rear of fire box, and just at the "bridge," have a hollow through them of 12 ins., so as to form a reservoir for hot air. Standing in these last three larger logs are uprights made of fire-clay, 3 ins. thick and 12 ins. on their flat sides, and having a hollow in them of 1 in. by 8 ins., extending from their lower open ends to within 1 in. of their upper ends (the upper ends being closed); the flat surfaces or sides of these uprights are perforated so as to spray hot air into the smoke and gases passing between them; and they set into the mortises in the large logs, and reach down and their hollows connect with the air reservoir in the large logs. The uprights stand 2 ins. apart, giving a smoke passageway of 2 ins. between each, and a space of 2 ins. at ends between last upright and wall of combustion chamber. The uprights in the middle one of the three large logs are set staggered (in relation to those in other two), so that the columns of smoke are split up by abutting against the upright next in its course. There is a blower at rear end of boiler, which drives the cold air first into a 6-in. iron pipe, making six convolutions longitudinal with boiler (10 ft. each), and lying imbedded in the left brick wall of the brick work of the boiler, which convolutions extend parallel with boiler from its rear end forward as far as the bridge, where it is turned back by knuckle joints (this is the primary heater, warming air so that contraction upon the fragile fire-clay logs will not cause them to break), and finally connected with the hollow in the first fire-clay log at rear of the boiler, the knuckle cap joints connecting the contiguous logs, making the air conduit continuous from the blower to the large air reservoirs in the last three large logs, and through the hollow uprights and their perforations.

Now fire up this furnace, and as soon as steam is raised start the blower (it is preferable to run it with an independent electric motor), and the air is driven into the convolutions of the iron pipe, passing 60 ft. through that, and receives its first heat and then passes into the first hollow log and continues to the uprights, by which time it is heated far above the flash point, and is sprayed, under pressure of the blower, into columns of smoke and gases from two sides, and produces instantaneous absolute combustion, with an intense white, incandescent heat, and the blower is kept running all the time, creating forced draft, and there is no smoke or gases whatever left to escape or to foul the tubes in boiler.

It will probably occur to most of our readers that the perforated uprights which constitute the bridge wall in the above device would be a pretty difficult thing to make of firebrick and when made would be apt to have a very short life; also that to force any considerable amount of air through the long and tortuous channel which has been provided for its preheating would not be an easy task. Both these difficulties were encountered. The inventor informs us that for three years he was unable to find a material which would stand. A few months ago, however, he found at Mineral City, O., a flint clay which when

TWO EXPERIMENTS IN SMOKE PREVENTING FURNACES.

We illustrate herewith two recent devices for securing improved combustion in boiler furnaces which have been brought to our attention and which are of interest from several points of view. Both are based on sound theories respecting the process of combustion and the essentials to be obtained to secure perfect combustion in burning bituminous coals. In both cases, however, the inventors seem to us to have "lost their perspective." In their anxiety to secure certain ends, they failed to remember the cardinal necessity of

mixed with imported German clay promised to give satisfactory results, as it withstood in tests a temperature of 3,600°.

A 56-in. × 16-ft. return tubular boiler at Mineral City was equipped with the device and tests were made with it Feb. 10 to 25 last. The blower used was a small fan only 16 ins. diameter by 4-in. face. This had to be placed 42 ft. away from the furnace. It delivered air into a 4-in. pipe which ran to the furnace, made back and forth turns inside one wall and then delivered air into the so-called "fire-clay logs" in the combustion chamber end and floor, which were made with a 5-in. hollow.

The results of the test are described as follows in a statement furnished us by the inventor:

The furnace was fired with soft coal, and when the blower was turned on it could be seen through the windows of mica in the side walls that from the small perforations in the uprights little jets of intensely white flame leaped. From this time on every witness present declared that the furnace was a three-fourths success. Immediately after opening the doors to coal up and when the doors were open with a green fire great volumes of black smoke were emitted from stack; but after closing the doors after firing, and within three to four minutes after, when the indications were that the furnace had regained the heat lost by opening doors, the smoke would clear up, and no more until another fire was to be built.

The fact that any smoke at all was passing through the white-hot uprights led to an investigation, and it was found that there was not enough air coming into the bridge logs to properly mix with the gases and smoke generated. This was proved by shutting down the furnace and cooling it off, when the writer entered the firebox and removed all the uprights, which were found badly cracked from the cold blasts of air coming through the doors when opened to fire.

The blower was now started with the writer in the firebox, and there was only enough air coming out of the mortises in the bridge logs to indicate a gentle breeze. As we had now demonstrated that we were on the right track towards burning the smoke, and further we had demonstrated that the best fire-clay built into hollow uprights for carrying the air were failures on account of cold air coming against them from the open fire doors when they were white hot, it was decided that we build around the openings in the bridge logs checker-work of firebrick and simply let the air come up from the bridge logs and percolate through the firebricks and mix there with the smoke and gases. The furnace was thus arranged and fired again, and as more air could come out of the bridge logs than could come through the small perforations in the uprights; this second trial demonstrated that at least nine-tenths of the smoke was consumed. When a green fire was made the smoke would not last over three to four minutes, and the whole interior of furnace clear back to rear was one mass of white flame.

Impartially analyzed, this test showed merely that forcing in highly heated air at the bridge wall tends to promote combustion and prevent smoke. There is nothing to indicate that such a method could be made a practical success for smoke prevention, except in combination with careful firing. When fresh coal is thrown upon a fire, it emits for a short time such great volumes of gas that a very large quantity of air indeed would be required to completely burn it. If provision is made to force in such large quantities of air at the bridge wall, there will be a large excess of air at all times except for a minute or two after firing, and the result will be a poor economy.

A COMPLETE COMBUSTION FURNACE FOR A LOCOMOTIVE BOILER.

The second apparatus to be described is a scheme for preventing smoke and securing complete combustion in a locomotive boiler, devised by Mr. Robert L. Walker, formerly of Pittsburg, but now of New York city, an engineer who has for many years made a specialty of devices for smoke prevention.

The accompanying drawings show a locomotive firebox fitted with the device, which was actually installed and operated for some time on a locomotive of the Delaware & Hudson Canal Co., hauling passenger trains on the local belt line between Albany and Troy.

It will be seen that the purpose of the device is to carry out the well-known principle of alternate side-firing, by which the gases generated from fresh coal thrown on one side of the firebox are supposed to be ignited by the heat from the incandescent coal on the other. A vertical water leg partition through the center of the firebox from front to rear divides it into two parts for the rear four-fifths of its length. Above this water leg is a movable water leg partition. A fire brick arch across the front of the firebox completes the control over the burning gases. The water-leg in the upper part of the firebox is mounted on trunnions, so that it can be swung from one side to the other, the swinging being done by a steam cylinder, rack and pinion mechanism. When the door is opened to fire on one side, the swinging leg is closed down on that side and the gases given off from the fresh coal have to pass to the front, around the end of the lower water leg and back over the incandescent coal on the other side in order to reach the flues. When it is desired to fire on the other side the "water leg damper" is swung over to the other position.

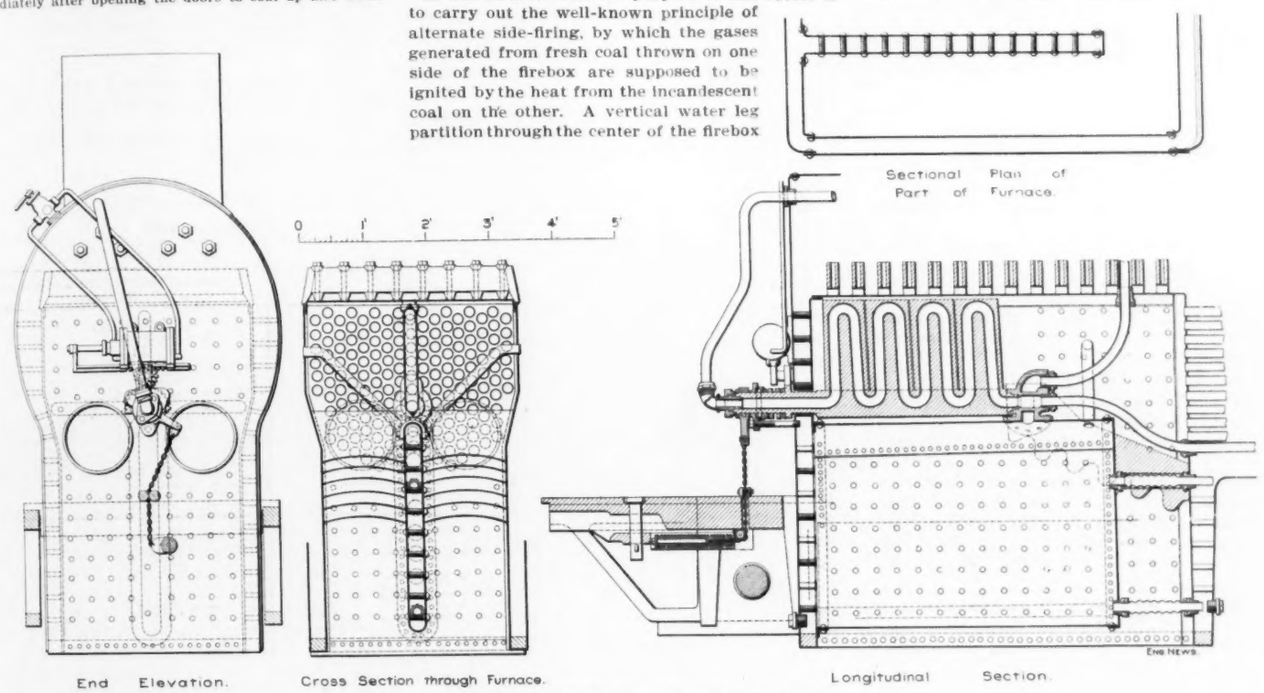
We do not know whether to admire more the ingenuity which the inventor has shown in solving the extremely difficult mechanical problems in connection with his device or his remarkable success in getting the device actually into service upon a locomotive belonging to a prominent railway company.

It is stated that the locomotive showed remarkable results in fuel economy and entire freedom from smoke; and we see no reason to doubt it; for everyone will agree that the principle on which the device is designed—passage of the gas from fresh fuel and an incandescent bed of coal—is an excellent one. For all this, the fact is patent that the apparatus is by far too fearfully and wonderfully complicated to be seriously considered as a permanent attachment to a locomotive firebox.

Since the above was in type we have discovered that substantially the same construction of a locomotive firebox as that shown above was brought forward by Mr. Walker more than 20 years ago and was put into use experimentally on several railways. It is illustrated in Vol. 17 of the Annual Reports of the American Railway Master Mechanic's Association, and it was referred to as follows in a report of a committee of the Association presented in June, 1884:

Plate 23 is an illustration of the Walker smokeless firebox as applied to a locomotive boiler, and with which a few of the members are familiar. This engine was being tried on one of our prominent roads running into Chicago during our meeting in that city last year. After being tried in the East it made its way out West, and, after having been given extended trials on some of our Western roads, it has finally disappeared.

It is fair to say that in his new apparatus illustrated above, Mr. Walker has introduced a number of improvements, such as the use of a steam cylinder to turn the partition in the firebox from one side to the other.



A SMOKELESS FIREBOX FOR LOCOMOTIVES.
Robert L. Walker, New York City, Inventor.

THE POLAR MOMENT OF INERTIA, AND ITS GRAPHICAL APPLICATION TO RIVETED JOINTS.

By C. F. Blake* and R. W. Runge.

Aside from the formula for the resistance of a shaft to torsion,

$$R = \frac{\pi}{16} d^3 f = f \frac{I_p}{y_p},$$

there is little evidence that engineers and designers are acquainted with the polar moment of inertia or its use. The general formula for torsion, however, which involves the polar moment of inertia, is easily and conveniently applicable to many problems of applied mechanics. The formula for equilibrium is exactly the same as in the case of bending, except that the polar moment of inertia (I_p), is substituted for the corresponding moment around an axis in the plane considered.

Thus, the torsional moment of resistance is:

$$M = f \frac{I_p}{y_p} = f z_p \qquad (1)$$

where

M = the resisting moment about the pole,
f = the fiber stress in the extreme fiber, corresponding to the moment M,
y_p = the distance from the pole to the extreme fiber (this is measured radially from the

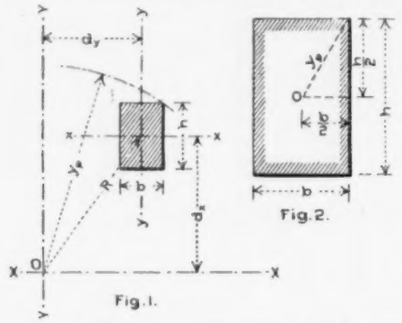
*Mechanical Engineer, Muskegon, Mich.

pole, and is therefore given the subscript $_p$),

I_p = the polar moment of inertia,

z_p = the polar section modulus.

If, when considering the torsional resistance of any section about a given pole, we draw through that pole the axes of a system of rectangular co-ordinates, XX and YY, the polar moment of inertia of the section will be the sum of the two co-ordinate moments of inertia about these axes. Thus, referring to Fig. 1, let I_x and I_y be the moments of inertia of the section about the x and



y-axes, respectively, these axes being drawn through the center of gravity of the section. The respective moments of inertia about the axes XX and YY are, respectively,

$I_X = I_x + A\,d^2_x$

$I_Y = I_y + A\,d^2_y$

where A = the area of the section.

Then, by the rule stated above, the polar moment of inertia about the pole O is the sum of the moments around XX and YY, or,

$I_p = I_X + I_Y = I_x + A\,d^2_x + I_y + A\,d^2_y$

$= I_x + I_y + A\,(d^2_x + d^2_y) = I_x + I_y + A\,R^2$,

in which last expression R is the distance from the pole O to the center of gravity of the area considered.

Where several separate areas (or cross-sections) are grouped about a single pole, the total polar moment of the group is the sum of the several polar moments taken separately, as above, for each section. Thus, for any number of sections,

$$I_p = \Sigma\,(I_x + I_y + A\,R^2) \qquad (2)$$

Substituting this value in (1) we have,

$$M = f\,\frac{\Sigma\,(I_x + I_y + A\,R^2)}{y_p} \qquad (3)$$

and

$$z_p = \frac{\Sigma\,(I_x + I_y + A\,R^2)}{y_p} \qquad (4)$$

The polar moment of inertia for each section in a group may be found for each section separately, and as the total polar moment of inertia equals the sum of the several moments thus found separately for each section, equation (1) becomes,

$$M = f\,\frac{\Sigma\,I_p}{y_p},$$

y_p being taken as the distance from the pole to the extreme fiber of the entire group.

POLAR MOMENTS.—When the different sections are rectangles, with dimensions b and h respectively parallel to the X and Y-axes, as shown in Fig. 1, we have, for each section,

$$I_x = \frac{b\,h^3}{12}$$

$$I_y = \frac{b^3\,h}{12}$$

and

$$I_x + I_y = \frac{b\,h^3 + b^3\,h}{12}$$

Substituting these values in (2) and (4) to get the values for the entire group around the pole O, we have,

$$I_p = \Sigma\,bh\left(\frac{h^2 + b^2}{12} + R^2\right) \qquad (5)$$

and

$$z_p = \frac{\Sigma\,b\,h\left(\frac{h^2 + b^2}{12} + R^2\right)}{y_p} \qquad (6)$$

For a single section of dimensions b and h, having the pole at its center of gravity, as in Fig. 2, these expressions become much simpler, since,

$$R = 0, \text{ and } y_p = \frac{1}{2}\sqrt{b^2 + h^2};$$

substituting these values in (5) and (6) we have,

$$I_p = \frac{b^3\,h + b\,h^3}{12} = \frac{b\,h\,(b^2 + h^2)}{12}$$

and

$$z_p = \frac{b\,h\,\sqrt{b^2 + h^2}}{6}$$

When the several sections are squares with sides parallel to the co-ordinate axes, we have for each section,

$$I_x = I_y = \frac{b^4}{12}, \text{ and } A = b^2.$$

Then the values for the entire group, around pole O, are found from equations (2) and (4) to be

$$I_p = \Sigma\,b^2\left(\frac{b^2}{6} + R^2\right) \qquad (7)$$

$$z_p = \frac{\Sigma\,b^2\left(\frac{b^2}{6} + R^2\right)}{y_p} \qquad (8)$$

For a single square section, with the pole at its center of gravity, R is again equal to zero, and the distance to the extreme fiber is,

$$y_p = \frac{b}{\sqrt{2}}$$

These values substituted in (7) and (8) give:

$$I_p = \frac{b^4}{6}$$

and

$$z_p = \frac{b^4}{6} \div \frac{b}{\sqrt{2}} = .235\,b^3$$

When the individual sections in a group are circles of diameter D, we have for each section,

$$I_x = I_y = \frac{\pi}{64}D^4 = .049\,D^4$$

and

$$A = .785D^2.$$

Then from Eq. (2) and (4) the values for polar moment and modulus, around any pole O, are found to be:

$$I_p = \Sigma\,D^2\,(.098\,D^2 + .785\,R^2) \qquad (9)$$

and

$$z_p = \frac{\Sigma\,D^2\,(.098D^2 + .785R^2)}{y_p} \qquad (10)$$

For a single circular section with pole at its center of gravity,

$$y_p = \frac{D}{2}, \text{ and } R = 0;$$

substituting these values in the preceding equations gives:

$$I_p = .098D^4$$

and

$$z_p = \frac{.098D^4}{\frac{D}{2}} = .196D^3$$

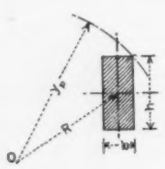
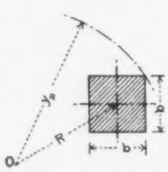
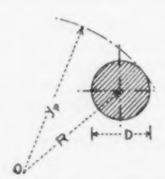
The foregoing equations are all perfectly general, no matter what the arrangement of sections around the pole may be, or what combinations of different sections may be made. An irregular shaped section may usually be readily divided into two or more of the foregoing sections, and its polar moment of inertia about a given pole calculated by adding the separate moments of the parts.

The following table makes a convenient summary of the polar properties of the plain sections:

TABLE I.—POLAR PROPERTIES OF SECTIONS.

$$M = f\,\frac{I_p}{y_p} = f\,z_p \qquad M = f\,\frac{\Sigma\,I_p}{y_p} \qquad r = \sqrt{\frac{I_p}{A}}$$

$$I_p = \Sigma\,(I_x + I_y + A\,R^2) \qquad z_p = \frac{\Sigma\,(I_x + I_y + A\,R^2)}{y_p}$$

Shape of Section.	I_p, z_p and r^2 about any pole P.	I_p, z_p and r^2 pole at center of gravity of section.
	$I_p = \Sigma\,b\,h\left(\frac{b^2 + h^2}{12} + R^2\right)$ $z_p = \frac{\Sigma\,b\,h\left(\frac{b^2 + h^2}{12} + R^2\right)}{y_p}$ $r^2 = \frac{\Sigma\,b\,h\left(\frac{b^2 + h^2}{12} + R^2\right)}{\Sigma bh}$	$I_p = \frac{b\,h\,(b^2 + h^2)}{12}$ $z_p = \frac{b\,h}{6}\sqrt{b^2 + h^2}$ $r^2 = \frac{b^2 + h^2}{12}$
	$I_p = \Sigma\,b^2\left(\frac{b^2}{6} + R^2\right)$ $z_p = \frac{\Sigma\,b^2\left(\frac{b^2}{6} + R^2\right)}{y_p}$ $r^2 = \frac{\Sigma\,b^2\left(\frac{b^2}{6} + R^2\right)}{\Sigma b^2}$	$I_p = \frac{b^4}{6}$ $z_p = .235b^3$ $r^2 = \frac{b^2}{6}$
	$I_p = \Sigma D^2\,(.098D^2 + .785R^2)$ $z_p = \frac{\Sigma D^2\,(.098D^2 + .785R^2)}{y_p}$ $r^2 = \frac{\Sigma D^2\,(.125D^2 + R^2)}{\Sigma D^2}$	$I_p = .098\,D^4$ $z_p = .196\,D^3$ $r^2 = .125\,D^2$

RIVETED JOINTS IN TORSION.—In a riveted joint subjected to torsional stress, the several areas or sections constituting the group about the pole are circles, being the cross-sections of the rivets. The pole is at the center of gravity of the group, or at the fulcrum if there be one. As it is usual to employ but a single size of rivets in any one joint, for constructional reasons, the several sections may be considered as of equal areas. Since for a circle $I_x = I_y$, Eq. (4) becomes,

$$z_p = \frac{\Sigma\,2\,I_x + \Sigma\,A\,R^2}{y_p}$$

or, I_x being the same for all of the n rivets,

$$z_p = \frac{2\,n\,I_x + \Sigma\,A\,R^2}{y_p}$$

The term $2nI_x$ is in all cases so small as to be negligible in practice, and its neglect being upon the side of greater safety in the joint, we have, approximately,

$$M = f\,z_p = f\,\frac{\Sigma\,A\,R^2}{y_p} \qquad (11)$$

in which f equals the shear per unit area at the extreme fiber due to the torsional moment.

Fig. 3 represents several rivets grouped about a pole P at the center of gravity of the system, the torsional unit-shear f being shown at the extreme fiber of the group, which, of course, is to be found in the rivet furthest removed from the

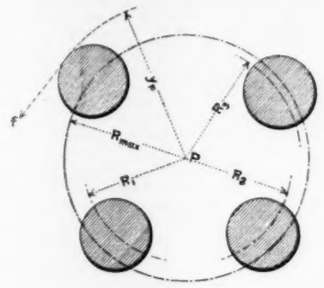


Fig. 3.

pole. The shear per unit area at the center of this rivet equals,

$$\frac{f\,R_{max}}{y_p}$$

But if we call the total torsional shear upon this rivet f_s, then $\frac{f_s}{A}$ will be the average unit-shear, due to torsion, over the whole area of the rivet, or it will be equal to the unit torsional shear at the center of this rivet. Then by equating these two expressions we have,

$$\frac{f_s}{A} = \frac{f\,R_{max}}{y_p}, \text{ or, } f = \frac{f_s\,y_p}{A\,R_{max}} \text{ and } f_s = \frac{f\,A\,R_{max}}{y_p} \qquad (12)$$

Substituting this value for f in Eq. (11), we find the expression for the resisting moment to be:

$$M = \frac{f_s\,A\,y_p\,\Sigma R^2}{A\,y_p\,R_{max}} = f_s\frac{\Sigma R^2}{R_{max}} \qquad (13)$$

The use of this formula involves obtaining the value of f_s, which is most easily done by the graphical method of Fig. 4. The drawing represents a rivet subjected to two forces, a direct vertical shear f_w, and a shear due to a torsional moment about the pole P. When considering the problem presented by this rivet, we find that the known elements are the direction and intensity of the vertical shear f_w, the direction of the shear f_s due to the torsional moment, this being normal to the radius P C in the direction of rotation, and the intensity of the resultant of the two shearing forces f_w and f_s. The value of this resultant is the total allowable shear upon the rivet, which may be taken from tables of shear-

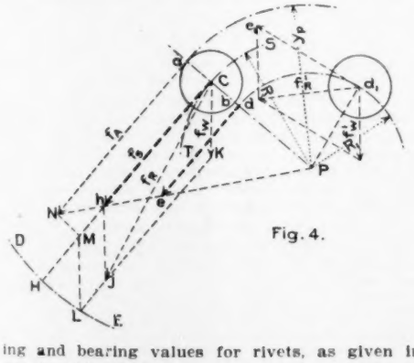


Fig. 4.

ing and bearing values for rivets, as given in structural handbooks.

From the center of the rivet draw D E with radius C L representing to some convenient scale the maximum shearing value of the rivet as found from the table.

Draw C H normal to P C in the direction of rotation about the pole P. Lay off from C the value of f_w to the same scale in the direction of the direct shear, vertical in all cases where this shear is due to gravity. Draw K L parallel to C H, and L M parallel to C K. Then the line C M represents the maximum allowable torsional shear upon the rivet, normal to C P, such that the resultant of this shear with f_w will not be greater than the allowable shearing value of the rivet.

If the direction of shear were a right line normal to C P, this value C M would represent the allowable shear in this direction on the rivet. The direction of shear, however, is represented by the arc S T struck from the pole P, and it will be observed that the larger portion of the rivet lies outside of this arc. To be correct the point C should be taken not at the center of the rivet as shown, but at a distance from P equal to the polar radius of gyration of the rivet about P, values of which are given in Table I. It is sufficiently accurate in practice, and much more convenient, to ignore this and take C as the center of the rivet.

The shearing value of the rivet taken from the handbook tables is based upon a certain uniform maximum unit stress upon the rivet. If the line C M represented not only the intensity but also the direction of the torsional component of C L, that is, if all fibers of the rivet were stressed equally, the problem would be completely solved by the preceding. However, as the direction of the torsional component is along the arc S T, it is evident that the fibers at a are strained higher than the fibers at b; and as the maximum fiber stress must not exceed that corresponding to the chosen shearing value of the rivet, this stress must be at a, and will then decrease from a maximum at a to a minimum at b. The value C M corresponds to the extreme fiber stress seen to be only upon the fibers at a, and must be resolved from a to the center of the rivet, as is done in equation (12). This is conveniently done graphically as follows:

Draw M N, parallel to P C, to intersect Na at N, and draw PN. Then Na = CM = fA, where f is the allowable fiber stress per unit area, and A = the area of the rivet. Also, Na × CP = f_s × Pa, or Ch = $f_s = \frac{Na \times CP}{Pa} = \frac{f\,A\,R}{y_p}$.

Draw h j parallel to C K. C j is the resultant, f_r, of f_s and f_w. The value of f_s thus found may be used in formula (13) where there are several rivets about the pole P.

A further precaution is necessary, however, since it is not always true that the farthest removed rivet is under the greatest resultant stress f_r. It has been shown that the moment of resistance of each section about the pole P is very nearly directly proportional to the square of its distance, R, from the pole. Therefore, if in Fig. 4 a second rivet is located at a distance R_1 from P, we may, through the center of that rivet, draw an arc cutting P C in d, and then parallel to C M draw d e representing the value of f_s for the second rivet.

From the center of the second rivet lay off f_w', in direction and intensity equal to f_w for the first rivet; also normal to d_1 P in the direction of rotation, lay off d_1 e_1 equal to d e. Complete the parallelogram of forces and find the resultant f_r' for this rivet. If this resultant f_r' is greater than the resultant f_r on the first rivet, a rearrangement of the rivets must be made, or more rivets introduced. In a given group of rivets it is not always apparent which rivet will be under the greatest strain, in which case any rivets under suspicion as being possibly subjected to a greater strain than the one assumed must be investigated similarly to the second rivet in Fig. 4.

Fig. 5 represents a horizontal plate riveted to a vertical support, and carrying a load of 4,000 pounds at a distance of 20 ins. from the pole P of the rivets. Assume ¾-in. rivets spaced as shown. Neglecting the weight of the plate, the vertical shear upon each of eight rivets from the load of 4,000 pounds is 500 pounds. The shearing value of a ¾-in. rivet, at 7,500 lbs. per sq. in., is found from the rivet tables in handbooks to be 3 300 lbs., which is the radius of the arc D E. Proceeding as in Fig. 4, we find f_s = 2,765 lbs. With P as the center draw circles through all the rivets of the group, and where each circle cuts the line P C draw tangents normal to P C. The length of each tangent between P C and P N represents the allowable torsional shear for each rivet upon its respective circle. The moment of resistance of any rivet is the product of its respective tangent f_s by the radius of its circle. Thus follows the rule: Multiply each tangent by the radius of the circle, and by the number of rivets on that circle; the sum of these several products is the moment of resistance of the riveted joint in question.

Or expressed as a formula,

$$M = \Sigma f_s\,n\,R = f_s\,n\,R + f_s'\,n_1\,R_1 + f_s''\,n_2\,R_2 + \text{——}$$

This may be derived from (13) in the form:

$$f_s\frac{\Sigma R^2}{R_{max}} = f_s\frac{n\,R^2}{R_{max}} + f_s\frac{n_1\,R_1^2}{R_{max}} + f_s\frac{n_2\,R_2^2}{R_{max}} + \text{——},$$

which is equal term to the preceding, since

$$\frac{f_s}{f_s'} = \frac{R_{max}}{R_1}, \text{ and therefore } f_s\frac{n\,R_1^2}{R_{max}} = f_s'\,n_1\,R_1$$

Using our rule to investigate the torsional strength of the joint shown in Fig. 5, we have,

$$M = \begin{cases} 2765 \times 4 \times 5 = 55300 \\ 2220 \times 2 \times 4 = 17760 \\ 1650 \times 2 \times 3 = 9900 \end{cases}$$

82,960 inch-pounds,

while the moment due to the load is 4,000 × 20 = 80,000 inch-pounds. Thus there is a margin of safety in the joint as shown.

Figs. 6 and 7 show two practical problems in the torsion of riveted joints. Fig. 6 represents a spliced I-beam for which each group of rivets should be treated as in Fig. 5, taking the moment at each pole P and P′ equal to the bending moment on the beam at that point. In Fig. 7, the rivet system is to be divided into two groups, one

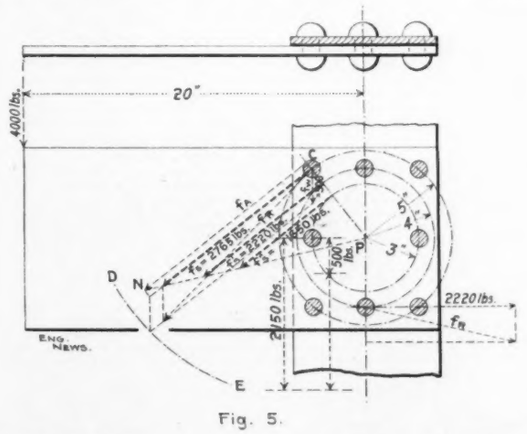


Fig. 5.

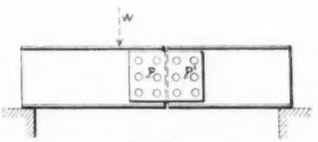


Fig. 6.

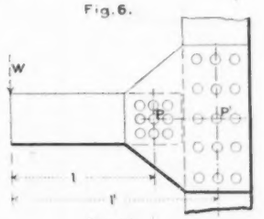


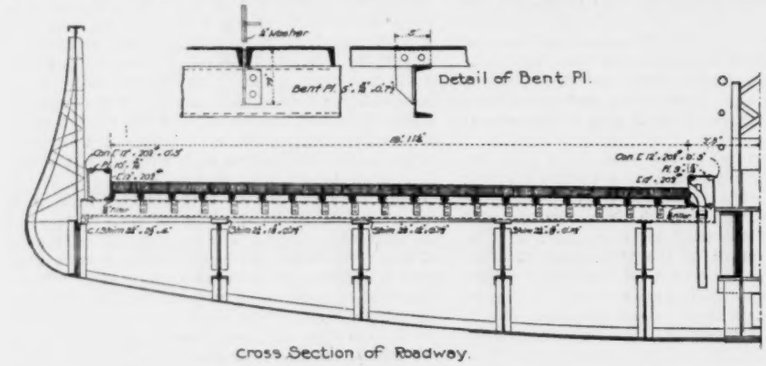
Fig. 7.

on each member, grouped about the poles P and P′, at which the moments are W l and W l′ respectively, and each group is then to be treated as in Fig. 5.

It will be noted that in this discussion we have dealt wholly with the shearing strength of the rivet, taking the value thereof from the rivet tables. Occasion will arise, however, in which the bearing value as given in the tables will be the determining factor instead of the shearing value. In such a case the bearing value may be treated throughout precisely as the shearing value has been in this discussion.

STEEL UNDERFLOORING AND WOOD BLOCK PAVEMENT FOR THE ROADWAYS OF THE WILLIAMSBURG BRIDGE.

Specifications for the construction of the steel underflooring and for the paving of the roadways for the Williamsburg Bridge have just been issued from the office of the Commissioner of Bridges, Mr. Gustav Lindenthal, M. Am. Soc. C. E., of New York city. These specifications are interesting chiefly because they call for a solid underfloor of steel covered by a paving of wood block. On the old Brooklyn Bridge the roadway consists of planking carried on the open framework of the roadway platform. The proposed roadway of the Williamsburg Bridge is a radical departure from this construction, first in being solid, and second, in being practically fireproof. As will be remembered by many of our readers the roadways of the Williamsburg Bridge are carried by cantilever brackets outside of the stiffening trusses. The ends of these brackets are connected by a solid girder, and between this girder and the truss ends of the brackets are four lines of stringers. A railing surmounts the end girder.



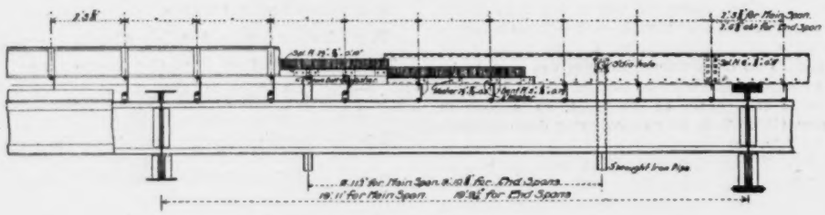


FIG. 1. SECTIONS OF ROADWAY OF WILLIAMSBURG BRIDGE, SHOWING CONSTRUCTION OF UNDERFLOORING AND WOOD BLOCK PAVEMENT.

Gustav Lindenthal, M. Am. Soc. C. E., Commissioner of Bridges, New York City; O. F. Nichols, M. Am. Soc. C. E., Engineer in Charge.

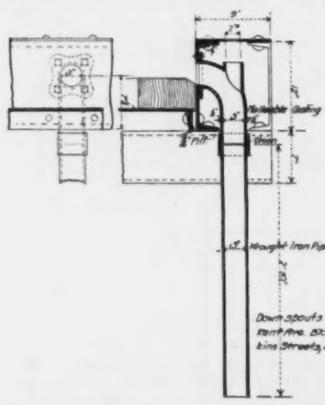


Fig. 2. Detail of Down Spout for Draining Roadway.

This construction is plainly indicated by the drawings of Figs. 1, 2 and 3.

UNDERFLOORING.—The construction of underflooring called for in the specifications is as follows: On the top of each bracket at points over the outside girder and over each stringer are set cast-iron shims. These shims decrease in thickness from the outer girder toward the truss ends of the brackets. On top of the shims and over each bracket a 7-in. channel is set on edge and riveted to the top flange of the bracket. These channels carry a solid flooring of 12-in. channels set with their legs downward, and close side by side; the 12-in. channels being riveted to the 7-in. channel by means of the bent plate connections shown by Fig. 1. The wood block paving rests directly on the tops of the 12-in. channels.

The material called for is open-hearth steel of 60,000 lbs. to 68,000 lbs. ultimate strength, 22% elongation and 44% reduction of area. The requirements for workmanship, testing and inspection are such as are ordinarily called for in first-class bridge work. Special treatment for the prevention of oxidation, is specified as follows:

As a preventive against oxidation all of the steel used in the work shall be especially prepared for and then covered with an enamel coating as herein described. As a preparation for the receipt of the enamel coating all of the steel channels used in the work shall have the mill scale completely removed from them on leaving the rolls, and shall then have applied to their entire surface while they are still hot a good coating of pure linseed oil or of other similar material approved by the engineer, the intent being to provide a surface of clean metal protected as far as possible from oxidation until the enamel coating can be applied, and that this prepared coating shall be one with which the enamel material will combine. All of the rivets, pipes, fittings, and small pieces, shall either be prepared in the same way for the receipt of the enamel coating, or they shall be carefully cleaned and coated in some other way approved by the engineer, before receiving the enamel coating. The steel shall then be coated by dipping in an approved compound and then baking it at a temperature of not less than 300° F. for not less than two hours; if the dipping compound is previously heated this shall be done by a flue and not by steam, the intent being to exclude moisture. The baking oven shall be similarly heated, and the products of decomposition shall be excluded from it, and the bottom of the oven shall not be so heated as to decompose the drip which may fall upon it; the whole operation being performed in a building which will protect the material from the weather. The coating shall in smoothness, hardness, toughness, elasticity, adhesiveness and resistance to chemical action, be equal, in the judgment of the engineer, to that produced by what is known as the "Sabin process," and the coating shall not vary in thickness more than 1-100-in. It shall be too hard to be scratched by the finger nail; it shall not fly when struck by a hammer, and when placed on samples of sheet iron or steel about 1-100-in. in thickness (commercially known as "tagger's iron") the coating shall not show cracks when bent 180° ten times on a radius of 1-16-in.

The coating shall not be affected by soaking at 70° F. for 48 hours in any of the following aqueous solutions: (a) Sulphuric acid of 1 3-10 specific gravity containing 40% of anhydrous acid. (b) Commercial strong hydrochloric acid containing 20% of anhydrous acid. (c) Acetic acid, containing 20% of anhydrous acid. (d) Saturated solution of carbonate of soda, containing 20% of anhydrous carbonate of soda. (e) Saturated solution of carbonate of ammonia, containing 20% of commercial dry carbonate of ammonia. The metal shall be kept clean up to and during the process and shall be protected at all times from abrasion, and the coating and handling shall be carefully and skilfully done. All rivet heads formed in the field and all parts of the work which have been accidentally abraded or marred in handling shall, after the entire completion of the work, be coated with three coats of paint to be approved by the engineer.

PAVING.—The specifications call for creo-resinate wood block pavement laid in asphaltic cement directly on the steel underflooring. The requirements for materials and workmanship are as follows:

MATERIALS.—The timber from which the blocks are made shall be long-leaf Georgia or Florida yellow pine, sound, free from sap, loose or rotten knots, or other defects which would be detrimental to the strength or endurance of the blocks. No second growth timber shall be used. The blocks shall be 4 ins. deep, 4 ins. wide and 8 ins. long. They shall be sawed so as to be uniform in depth and planed so as to be uniform in width. No variation in depth or width greater than 1-16-in. will be allowed. Except for a distance of 300 ft. in each direction from the middle of the bridge the blocks shall be rebated on the upper outer edges with a rebate ¼-in. in thickness and 1½ ins. in depth below the top surface of the block; this rebating is to be skilfully done by machine before the blocks are treated, and the blocks shall be rebated in the same manner on the under side to accommodate the expansion angles laid on top of the channels. In the creo-resinate treatment of the blocks they shall be placed in an air-tight cylinder, and when the doors are closed the dry heat is to be raised to 250° F., and maintained at this temperature without pressure for one hour to remove moisture. The heat is then to be increased and atmospheric pressure applied, and both heat and pressure are to be raised gradually to avoid injury to the fiber for two hours until the heat has reached about 285° F., and the pressure about 90 lbs., and both will be held at these figures for one hour. The heat is then ta be shut off and the tanks are to be allowed to cool gradually for one hour. At the end of this time the heat is to be raised to 250° F., and the pressure to about 40 lbs. The pressure is then to be removed, and the heat still further reduced. The air is then to be exhausted from the cylinder until a vacuum of about 26 ins. is reached, and while under this vacuum the creo-resinate mixture is to be run into the cylinder at a temperature of 175° to 200° F., and a pressure is to be applied reaching 200 lbs. per sq. in., and held at this point until 21 to 22 lbs. of the mixture per cu. ft. has been absorbed. The liquid is then to be run off and the wood is to be placed in another cylinder and milk of lime at a temperature of about 150° F. is to be run in and a pressure of about 200 lbs. to be applied and maintained for half an hour to one hour. The asphaltic cement for filling the joints, etc., shall be composed of 20 parts of refined asphaltum, 3 parts of residuum oil and 100 parts of coal tar, known at the works as No. 4, and shall be used in all cases at a temperature of 300° F., and shall be heated in a tank holding about 10 barrels.

WORKMANSHIP.—The blocks are to be laid close and in straight courses at right angles to the curbs breaking joints, and brought to a uniform surface on top. They are to be driven together as tightly as possible at every sixth row, and at the expansion angles the blocks must be driven together by strong wedges or by jacks, as the engineer may direct. The blocks shall be bedded on the steel underflooring by either coating the channels with a heavy coat of hot asphaltic cement and setting the blocks in this cement with a paving hammer, or by dipping the bottom of the block for an inch of its depth in hot asphaltic cement, and then setting the blocks thus dipped with a paving hammer, the engineer to determine

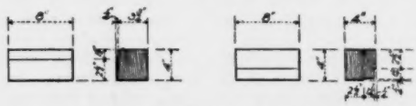


Fig. 3. Details of Rabbeted Paving Blocks.

which of these methods shall be pursued. The rebated joints shall be filled with a screened, fine selected gravel, never coarser than ¼-in. in greatest diameter, rammed into the joints with a calking iron, and all the joints, whether rebated or not, shall be filled with asphaltic cement or with the creo-resinate mixture heated to 300° F., as the engineer may direct. The filling for the joints may be required to be poured over the entire surface of the paving, and thoroughly swept into the joints with a wire broom. If the engineer shall direct, a filling of dry-screened sand may be required for the joints which are not rebated, and this sand may be required to be spread over the surface of the pavement after it is completed, in which case the depth of this sand coating will not exceed ¼-in. in thickness; or screenings of crushed stone may be substituted for sand in this covering coat.

A DUST-ARRESTING RESPIRATOR for use in dusty processes and dangerous trades is the subject of a prize competition inaugurated by the Society of Arts. The prize is £20 ($100) and the competition closes on Dec. 31, 1903. The following conditions which such an apparatus must fulfill are outlined in the announcement:

(1) It must be light and simple in construction. (2) It should be inexpensive, so as to admit of frequent renewal of the filtering medium or of the respirator as a whole; or alternatively it should be of such construction that it can be readily cleaned. (3) It should allow no air to enter by the nostrils or mouth except through the filtering medium. (4) It should not permit expired air to be rebreathed. (5) The filtering medium, though it should be effective in arresting dust particles, should not offer such resistance as to impede respiration when worn for some hours under the actual conditions of work. (6) It should be as little unsightly as possible.

The problem is restricted to dust-arresting respirators, since respirators for arresting poisonous fumes are of more limited application and are involved in special conditions. The solution offered may be for dust of all kinds or for dust of some special character, as iron or steel. Specimen respirators for this competition should be sent to the Secretary of the Society of Arts, John St., Adelphi, London, W. C., England. The specimens must be accompanied by full description, and any cases of actual use must be cited. Patent protection should be obtained before sending in the specimens. The competition is not limited to British subjects.